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Then and Now

Perhaps it is current events which prompt us to recall the changes which have taken place in foundry practice during the last twenty-five years. The most striking change perhaps is in the personnel of the industry. In 1914, the number of foundrymen with any claim to a knowledge of metallurgy was very limited, and mainly restricted to the large steel foundries. Yet one cannot say that the British Foundrymen's Association (as the Institute of British Foundrymen was then called) was the repository of really practical Papers as it is to-day. The most popular lecturers at that time were Sir Harold Carpenter, Dr. Longmuir, Mr. F. J. Cook and Mr. Robert Buchanan, whilst the general membership was composed of foundry owners, managers and foremen anxious to familiarise themselves with the "new" science.

There were a larger number of foundries of smaller capacity than to-day, and their equipment, with few exceptions, was primitive. New types of American moulding machines were beginning to enter the industry, and were not too well received by the operatives, and strikes against their use were not unknown. Light-alloy foundries were few and far between, whilst the making of magnesium castings had not yet been started. Much interest at that time was being evinced in "semi-steel" and the new oil-sand method of making cores. Sand control was based on experience, and it was the difficulty of obtaining Belgian sand during the War which led to Prof. Boswell undertaking a survey of British moulding sand resources. Mechanical handling within the industry was limited to overhead and jib cranes, supplemented in rare cases by a runway, the use of conveyors being entirely neglected. Despite the large number of foundries which existed, the industry was somewhat out of balance. There was a dearth of foundries specialising in the manufacture of malleable pipe fittings—a deficiency which has been made good to-day by the creation of some very large plants. Certain sections of the non-ferrous foundry industry were also ill-equipped for war demands. It is just about 25 years ago since the electric furnace established itself as a melting unit, and during the War period about a hundred plants were put into commission. The steel-foundry industry mirrors pretty faithfully war activity, and during the lowest ebb of the post-war depression its annual production approximated the output now being made by the largest concern in the industry.

Much of the progress in the mechanised production of castings is due to the efforts made by the motor-vehicle industry. This system has spread to dozens of other types of foundries, and even the smallest are continually seeking to apply what they can of the newer methods. The help given to the foundryman by the suppliers of pig-iron and the like was of major importance in 1914, and to-day this help still continues, but on a much more scientific basis. The quality of the product of both ferrous and non-ferrous foundries has materially improved. Taking tensiles as a criterion for cast iron, we estimate that there has been a general overall improvement of 4 tons per sq. in. As for dimensional accuracy, we know of steel castings being specified in thousandths of an inch. Naturally this is for a very special job, and commands a correspondingly high price.

Foreign visitors to the recent International Foundry Congress have confessed to us that before their tour of the various works they thought their own country led Europe in up-to-date methods for the production of castings, but returned with the conviction that this country now holds the first place. This leadership will only continue so long as the graduation from the foundry floor to the manager's office or the board of directors continues. The Continental system of limiting the progress an operative can make to the position of foreman, and drawing the whole of the members of the staff above that grade from the college and university graduates, does not make for a balanced industry. The progress which the foundry industry has made in this country has been largely due to the heterogeneous character of its make-up, reinforced by the whole-hearted co-operation of the engineer.

It is a very different foundry industry which faces the crisis of 1939 from that of 1914, and its contribution to armaments can, if necessary, be of a very material character.

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Indian Imports of Foundry Products

A Survey of the Import Trade of India for the Fiscal Year April 1, 1938, to March 31, 1939, prepared by H.M. Senior Trade Commissioner in India, has just been issued by the Department of Overseas Trade. The following extracts relate to imports of machinery, cast pipes and fittings, and rails, chairs and fishplates (rupees one lakh = £7,500 at 1s. 6d. exchange).

Machinery

Boilers.—This valuable trade continues to expand. The total imports increased from Rs. 117 lakhs to Rs. 140 lakhs. The United Kingdom continues to enjoy a dominating position in this trade, her exports advancing from Rs. 95.3 lakhs to Rs. 122.6 lakhs. Arrivals from Germany declined considerably from Rs. 9.4 lakhs to Rs. 5 lakhs. The share of "other countries" was maintained at approximately Rs. 12 lakhs.

Metal Working Machinery, including Machine Tools.—There was a small advance in the aggregate imports from Rs. 36.1 lakhs to Rs. 39 lakhs. Arrivals from the United Kingdom expanded from Rs. 21.8 lakhs to Rs. 25.7 lakhs, and from Germany from Rs. 5.2 lakhs to Rs. 6.3 lakhs. The share of the U.S.A. was stationary at Rs. 5.2 lakhs.

Mining Machinery.—The aggregate trade registered a sharp advance from Rs. 17 lakhs to Rs. 25 lakhs. The whole of this increase was enjoyed by the United Kingdom, whose sendings expanded from Rs. 5.3 lakhs to Rs. 14.3 lakhs. On the other hand, arrivals from the U.S.A. contracted slightly from Rs. 9.2 lakhs to Rs. 8.7 lakhs.

Oil Crushing and Refining Machinery.—This trade also showed marked expansion from Rs. 22.8 lakhs to Rs. 44.2 lakhs. The advance was, however, mainly shared by Germany and the U.S.A., whose shipments expanded respectively from Rs. 7.7 lakhs to Rs. 14.4 lakhs and from Rs. 5.2 lakhs to Rs. 18.4 lakhs. Arrivals from the United Kingdom, although not increasing to the same extent, expanded from Rs. 6.5 lakhs to Rs. 9.2 lakhs.

Paper Mill Machinery.—The year 1937-8 registered a very marked increase in the aggregate imports to Rs. 44.9 lakhs. This increase, however, was not maintained, as the imports during the year under review declined to Rs. 27.7 lakhs. Details of countries of consignment are not available.

Pumping Machinery.—There was a small decline in the aggregate imports from Rs. 36.2 lakhs to Rs. 34.7 lakhs. The United Kingdom, however, practically maintained her trade at just over Rs. 22 lakhs. The next nearest competitor, Germany, increased her shipments from Rs. 4 lakhs to Rs. 5.3 lakhs, while the imports from the U.S.A. declined from Rs. 5.8 lakhs to Rs. 4.8 lakhs.

Rice and Flour Mill Machinery.—The aggregate trade suffered some contraction from Rs. 8.8 lakhs to Rs. 6.8 lakhs. Arrivals from the United Kingdom declined from Rs. 4.3 lakhs to Rs. 4 lakhs; from Germany from Rs. 2.2 lakhs to Rs. 1.2 lakhs and from the U.S.A. from Rs. 0.74 lakh to Rs. 0.7 lakh.

Sugar Machinery.—There was a small decline in the total imports from Rs. 69.5 lakhs to Rs. 61.4 lakhs. This loss was suffered entirely by United Kingdom suppliers whose sendings declined from Rs. 43 lakhs to Rs. 30 lakhs. On the other hand, imports from Germany advanced slightly from Rs. 12.6 lakhs to Rs. 13.9 lakhs and from the Netherlands from Rs. 1.5 lakhs to Rs. 2.2 lakhs. Shipments from "other countries" increased appreciably from Rs. 12 lakhs to Rs. 15 lakhs.

Cotton Textile Machinery.—There was a small decline in the aggregate value of this trade from Rs. 292 lakhs to Rs. 267 lakhs. The United Kingdom and the U.S.A. suffered reductions in trade while Germany and Japan showed some increase. Arrivals from the United Kingdom declined from Rs. 236.6 lakhs to Rs. 196.4 lakhs and from the U.S.A. from Rs. 6.7 lakhs to Rs. 3.8 lakhs. The sendings of Germany advanced from Rs. 22 lakhs to Rs. 32 lakhs and from Japan from Rs. 15.7 lakhs to Rs. 17.9 lakhs.

Jute Machinery.—There was a decline of about 30 per cent. in the total value of imports from Rs. 106 lakhs to Rs. 71 lakhs. Particulars of countries of consignment are not available.

Sewing and Knitting Machines.—The aggregate imports showed an appreciable decline from Rs. 71.5 lakhs to Rs. 49.6 lakhs. This decline was shared by all the countries of supply. Arrivals from the United Kingdom fell from Rs. 43.6 lakhs to Rs. 28.4 lakhs and those from Germany from Rs. 22.9 lakhs to Rs. 18 lakhs. Sendings of "other countries" fell from Rs. 5 lakhs to Rs. 3 lakhs.

Cast Pipes and Fittings

This import trade, which is almost entirely in the hands of the United Kingdom, advanced from 1,426 tons, valued at Rs. 7 lakhs, to 2,546 tons, valued at Rs. 9 lakhs. The arrivals from the United Kingdom advanced from 1,318 tons, value Rs. 6.4 lakhs, to 2,450 tons, value Rs. 8.4 lakhs.

In the event of this country being involved in a European war, "The Foundry Trade Journal" and its associated publications will be transferred from London to 3, Amersham Road, High Wycombe.
(Telephone No. High Wycombe 1792.)

Rails, Chairs and Fishplates

The aggregate trade registered an appreciable advance from 7,471 tons, valued at Rs. 11 lakhs, to 11,469 tons, valued at Rs. 14.7 lakhs. The arrivals from the United Kingdom showed a sharp advance from 980 tons, value Rs. 2.6 lakhs, to 2,350 tons, value Rs. 5.5 lakhs. On the other hand, the arrivals from Germany fell very considerably from 3,633 tons, value Rs. 4.9 lakhs, to 2,514 tons, value Rs. 2.9 lakhs. The imports from "Other Countries" expanded from 2,769 tons, value Rs. 3½ lakhs, to 5,585 tons, value Rs. 5¼ lakhs.

Oxy-Acetylene Convention

At a convention to be held on the occasion of the Welding Exhibition (Engineering and Marine Exhibition) at Olympia on September 19, a series of six Papers will be discussed. The following Papers will be dealt with in the morning session, 11 a.m. to 12.30 p.m.

(1) "The Application of Oxy-Acetylene Welding and Cutting to the Manufacture and Repair of Locomotives," by A. C. PAGE and G. FOSTER. (2) "Permanent Way Welding," by N. W. SWINNERTON. (3) "Acetylene as an Aid to Navigation," by ASHLEY JULER, and at the afternoon session, 2.30 p.m. to 4.30 p.m., (4) "Burning during Welding of Mild-Steel Sheet, by DR. T. SWINDEN and DR. H. SUTTON. (5) "Bronze Welding of Cast Iron for Supply Mains," by F. W. HARPER. (6) "Welding of Pressure Pipe Lines," by C. G. BAINBRIDGE.

It is hoped that as many members as possible will attend and take part in the discussion.

Random Shots

Bad luck seems once again dogging the footsteps of Mr. Kenneth Bridges in his arrangements for the Marine and Shipping Exhibition, which is due to be held at Olympia in a fortnight's time. This time it is the international situation. Everyone hopes for a peaceful settlement of the present situation, and particularly that this exhibition will be saved from the same fate as the one which was planned for September, 1914. On that occasion the outbreak of war caused a postponement of five years!

* * *

International situations are not the only hazards with which exhibition organisers have to contend, however, for internal disturbances from time to time cause them just as much worry. One foundry exhibition was held during the General Strike of 1926, and on another occasion an Engineering Exhibition was overshadowed by the national mourning caused by a royal death.

* * *

As if this were not enough, even local authorities can cause quite a disturbance. They seem to have the unhappy knack of choosing the most awkward moment for tearing up the surrounding streets.

* * *

So far, the only disturbances not yet recorded are those which insurance companies delight in calling "Acts of God." No exhibition has yet been spoilt by flood, earthquake or lightning, nor has an army of locusts been known to rain from the heavens upon Olympia or Earls Court. The lot of the Exhibition Organiser, to "Marksman's" mind, is not a happy one!

* * *

Mr. Ernest Wells, lunching the other day with Mr. Gibson, a prominent Australian engineer, told a good yarn of life "down under." A rancher and his son had lived in glorious solitude for many years on their holding way out beyond the backwoods. Their ranch had prospered and they had amassed quite a nice balance at the bank. At last came the day when the father thought that his son ought to take a holiday and see a bit of the world. Accordingly the son set off, and after ten days in a bullock wagon, he reached a single track railway, which took him to the nearest "one-horse" town. Here he proceeded to have his good time at the local cinema and gin palace. Moreover he had the good fortune to meet a very charming girl to whom he very quickly proposed marriage. After a short honeymoon he took her back to the ranch where he settled down once again to the rigours of his former life. Father then announced that it was now his turn for a little jaunt, and off he went for a tour round the world. After two years he returned, anxious to see the progress his son had made in his absence.

"Aye, Father, I've done well. I got a good price for last year's clip; got another 1,000 sheep; been lucky with the cows and have just started breeding a few horses."

"And how's the wife?" asked his father.

"The wife? That's the only bit of bad luck I've had. She fell down and broke her leg, so I had to shoot her."

* * *

Amongst the questions in a popular newspaper feature recently was one which asked up till what year was the Act still in force which forbade motor vehicles to travel more than 20 miles per hour. It is surprising to find, in these days of a speed of 70 on the open road, 300 on the salt flats, and 400 or more in the air, that the law was still in operation in 1931!

"MARKSMAN."

Metallurgy in Foundry Practice

VIEWS OF INTERNATIONALLY-KNOWN EXPERTS

Apparently there was some little hesitancy on the part of the well-known leaders of metallurgical thought to criticise each other's work when they were brought together under the chairmanship of Major R. Miles for the session of the London International Foundry Congress which was devoted to theoretical concepts of the metallurgy of cast metals.

CRYSTALLISATION IN COMMERCIAL ALLOYS

The session was opened by the presentation of the Paper by Mr. W. Patterson on "Process of Crystallisation in Commercial Alloys" (published in our August 10 issue).

The first speaker was Professor A. Portevin (France), who remarked on the perfection of the curves produced by the author, which represented a further step towards the completion of the work performed by Tammann and Professor Piwowarsky, and showed a new application of thermal analysis. In order to obtain such perfect curves, he said, it was necessary to use very accurate methods and very precise apparatus for measurement, which was not always available; without such methods and apparatus it would not be possible to obtain the precise quantitative results given. It was a new application of precision thermal analysis.

With regard to the double supercooling effect, Professor Portevin raised the question as to whether a possible distinction should be drawn between the cases where, before the eutectic cooling occurred, the first modification had already taken place. He suggested that in that case, possibly, there was no direct effect on the structure of the metal, whereas in those alloys where both those effects took place, it was possible that that might be the cause of the change in the structure. The nature of the pro-eutectic constituent might act upon the eutectic structure in a different way, according to whether it was or was not the "directive constituent" of the eutectic aggregate.*

Professor E. Piwowarsky (Germany) said that where there was a break in the curve of the eutectic crystallisation it was always possible to distinguish a change in the structure of the metal. One part of the curve was definitely to be correlated with the existence of a coarse structure, and the other part of the curve with the fine structure in the metal.

THE COMPOUNDING OF ALLOYS

The Report on this subject from the Association Technique de Fonderie de Belgique (see the Journal for August 10) was then presented in abstract form by Mr. J. Léonard (Past-President, International Committee of Foundry Technical Associations), who said that the Report resulted from a suggestion by his French colleagues at the Warsaw Congress, and constituted a modest addition to the study of alloys. There were certain general principles which must be regarded as applicable to all foundry work, and those principles might have to be adjusted in one direction or the other according to the peculiarities of a particular metal that was being dealt with. The Report did not pretend to present original experimental results; it was a work of collation of daily workshop practice, and its object was to bring some sort of order into the inferences which might be drawn from that daily practice.

There was no discussion, but Mr. H. H. Shepherd (Ipswich), in a written communication, observed that he had read the Paper with a great deal of interest, and very much valued the appreciative statements made in this Paper with regard to the British Exchange Paper which he had presented to the International Foundry Congress held in Paris during 1937.

The English translation of that part of the Belgian Paper which referred to the writer's review of malleable melting practice stated, "This leads to the belief that Mr. Shepherd agrees as to an increase of oxidation with increasing temperature." This was not quite his view.

Increasing temperature did not, in his experience, necessarily give rise to increased oxidation. The extent of oxidation depended largely on the type of melting medium, and more particularly on the possible and actual extent of control. When he was writing on the melting of steel scrap charges in connection with oxidation, he had in mind cupola practice, which was not subject to careful control, and in this case super-heating could easily result in excessive oxidation. On the other hand, it was the writer's view that super-heating could be achieved, and particularly with certain types of melting media such as the electric furnace, without excessive oxidation.

Table A.—*Gas Content of Superheated Grey Cast Iron as Determined by the Vacuum Fusion Method (from the Paper by Di Giulio and White).*

Heat No.	Superheating temperature. Deg. F.	Oxygen. Per cent.	Hydrogen. Per cent.	Nitrogen. Per cent.
1	2,570	0.0097	0.00008	0.0033
2	2,730	0.0057	0.0001	0.0057
3	2,855	0.0076	0.0001	0.0073
4	3,035	0.0058	0.00003	0.0056
5	3,085	0.0041	0.00015	0.0011
6	3,110	0.0033	0.00008	0.0026

The translation of the Belgian Paper also gave the following: "He states that in general the solubility of gases diminishes when the temperature 'rises.' It would be interesting to have this point settled during the course of the London Congress."

In support of the view which the writer expressed as above, he would quote from a Paper by A. Di Giulio and A. E. White, "Factors affecting the Structure and Properties of Grey Cast Iron" (A.F.A. Preprint No. 35-9): "P. Bardenheuer believes with Piwowarsky that a further important effect of super-heating is the elimination of gases, which makes a denser structure possible." Later in the same Paper under the sub-heading "Investigation of the Gas Content of Superheated Cast Iron" it is stated:—

> "The results of this investigation are given in Table IV. Unfortunately, the results obtained do not show any possible correlation with the preceding findings. Close examination of Table IV [Table A above] will show the following facts to be true:
>
> "(1) Hydrogen and nitrogen contents of the superheated irons do not seem to vary in accordance with any law.
>
> "(2) Oxygen content decreases with an increase in superheating temperature.
>
> "This latter fact is in agreement with expectations, since it has been proved that, in general, the solubility of gases in metals decreases as the temperature increases."

The writer would submit that the above information, which was claimed to be supported by E. Piwowarsky and P. Bardenheuer, corroborated the statements which he made in the Paper to which the Belgian Association had made reference, and it was hoped that this would clear up the points in question. At the same time, the writer would be pleased to have further observations.

Mr. Léonard's Reply

In a reply by Mr. J. Léonard, on behalf of the Technical Committee of the Belgian Association, it was stated that two questions were asked: (1) Did an increase in temperature bring about a stronger oxidation? and (2) did the volume of dissolved gas vary in the same sense as the melting temperature?

The first question was best answered by pointing out that this factor should only be determined if all other conditions were equal. To compare the results obtained in different furnaces did not appear to be desirable. The opinion was maintained that excessive oxidation was brought about by superheating, in the case of cupola melting. The reply, however, did not remain indecisive, and in any given furnace melting in an atmosphere of constant composition, one could without equivocation state that oxidation increased with the temperature, the atmosphere being obviously oxidising.

So far as the second question was concerned, it might be asked whether the figures tabulated by Di Giulio and A. E. White were convincing. The Belgian Association, like Mr. Shepherd, were sceptical of the reliability of the hydrogen and nitrogen figures, because the irregularities shown permitted of the supposition of analytical errors, due either to manipulation or method used. The close agreement of the oxygen contents was impressive, in spite of the low figure of 0.0057 corresponding to a temperature of 1,500 deg. C. However, it should be noted that in the temperature interval of 258 deg. C. (from 1,410 to 1,668 deg. C.), it seemed permissible to speak of a lowering of the oxygen content. The two low contents gave the clear impression of a diminution when related to two adjacent temperatures (1,696 to 1,710 deg. C.).

The only conclusion it was thought possible to be drawn from these six results was that, at about 1,675 deg. C., the O_2 content remained practically constant, and that above this temperature there was a sharp drop. The results of Di Giulio and White should be considered as relating to an iron carried to a single superheating temperature but cast at different temperatures. It was thus not the influence of superheating but rather the effect of casting temperature that was thrown into relief.

On the other hand, so far as the O_2, H_2 and N_2, and the CO and CO_2 gases were concerned, it might be asked whether they were encountered in cast iron. The writer had noted with interest the evolution of their contents, for it was not impossible that, at very high temperatures, the affinity of oxygen for carbon might not be preponderating in relationship to that of O_2 for the other elements, Si, Mn, of the iron and that, in spite of the feeble mass of the O_2 being able to render this passive in a very large measure, a reaction of the C with the oxygen did not lower the volume occluded with the latter, but in replacing it by a volume of CO_2 or 2 volumes of CO.

The above was evidently not favourable to an increase of volume in which credence was placed; however, one could not ignore these opinions of pinholes and blowholes coming from the metal and placed against the action of superheating.

The writer was pleased with the decision of the International Committee of Foundry Technical Associations to place the question of gases dissolved in alloys on the programme for the Italian Congress in 1940. It now only remained for the writer to thank Mr. Shepherd for having started the discussion. It was well worthy of considerable expansion next year in Rome.

ALLOY COMPOUNDING BY MELTING

Following upon this was the presentation of the Paper on "General Principles Applicable to the Compounding of Alloys by Melting," by Professor Albert Portevin (see page 157 *et seq*).

* A. Portevin, "Structure of Eutectics," Institute of Metals, March, 1923.

PROFESSOR PORTEVIN, introducing his Paper, said that the work discussed therein arose from the French proposal at the Warsaw Congress to study the compounding of alloys. Being a Professor, he had felt it his duty as a student of the subject to collect and collate all available knowledge. The Paper was, however, the first review of the subject and was necessarily incomplete. He hoped that discussion might enable him to improve on his methods and results. The Paper, he said, was perhaps somewhat doctrinaire and absolute and he asked particularly that those who had practical experience of foundry work would give him the benefit of their criticisms, which would help his students and himself to modify and improve upon the results already obtained.

PROFESSOR E. PIWOWARSKY (Germany), in thanking Professor Portevin for an exceedingly valuable report, said that the materials covered therein were perhaps the most important of all which were before industry at the present time. When using metals, it was necessary to ensure that they were melted properly and that the correct after-treatment was carried out; all the various operations must be subject to close control, and that control must be exercised by someone who combined industrial knowledge of practical conditions with a scientific metallurgical background, such as Professor Portevin had supplied. Speaking metaphorically, he said it was a question nowadays not merely of making bricks, but of building the bricks into a wall by means of a mortar which was represented by the kind of knowledge that Professor Portevin had brought forward. Only in that way could the requirements of modern conditions be fulfilled.

THE CHAIRMAN (Major Miles) highly commended the logical way in which the Paper had been presented, particularly as it involved so many practical details.

Preventing Sulphur Pick-Up

MR. R. CHAVY (France) pointed out that alloys of high nickel content absorbed sulphur gases very easily, and inasmuch as very high sulphur content oils were now being used in melting furnaces in France, some difficulties were encountered due to some of the castings produced being very brittle. In order to overcome that difficulty, some silicon was added at the beginning of the melting to reduce the sulphur pick-up by the metal, and as a result much better castings were produced. It would be preferable to add the silicon at the end of the melt, but it was done at the beginning to protect the bath against the atmosphere.

Professor Portevin's Reply

PROFESSOR PORTEVIN also commented that the example given by Mr. Chavy was one in which an addition was made at the beginning of the fusion; it is an example of "protective" addition against alterations due to the atmosphere; it is consequently different from the case of final deoxidising or desulphurising additions.

COPPER AND COPPER-ALLOY CASTINGS

After two Papers by Dr. J. A. Vero and Mr. N. Chvorinov had been formally presented in the absence of the authors, Mr. H. J. Miller, M.Sc., presented his thesis on "Copper and Copper-Alloy Castings for Electrical and Thermal Conductivity Applications." This appeared in our last two issues.

MR. MILLER first apologised for the omnibus nature of the Paper. He had been compelled to deal with a wide range of alloys, and this point alone might be taken as signifying difficulty in meeting the requirements of electrical engineers and others. However, he had been impressed by the considerable range of brasses and bronzes used, and thought that there was little justification for the use of such a range of alloys. Hence, efforts which would result in standardisation were to be highly commended; tribute must be paid to the work of the Non-Ferrous Technical Sub-Committee of the Institute of British Foundrymen, which had issued valuable reports on leaded bronzes and gunmetal. As against this use of a multitude of cast bronzes and brasses, the electrical and mechanical properties of which were not widely different, he had been impressed by the development of other alloys permitting the attainment of special combinations of conductivity and strength. Thus, while on the one hand it might be said that the number of the older alloys could be reduced, yet it must be recognised that some of these newer materials were advantageous. These alloys as yet were in the early stages of development, but he believed that their future use in the electrical industry would be very wide.

Electrode Holders

MR. T. KROGVIG (Norway), after a tribute to the author, said that the usual commercial alloys which were mentioned did not include the one alloy which was used in Norway for large electrode holders for electric furnaces; it was an alloy containing about 15 to 17 per cent. zinc, the remainder being copper. He asked whether the author was of the opinion that that was a better alloy than those containing 25 per cent. zinc. It was not so easy to cast as were those containing 25 per cent. zinc, so that if it did not give better service than the latter, there was no reason for using it.

MR. MILLER was interested in the fact that in Norway they had been able to standardise on an alloy containing 83 to 85 per cent. copper and 15 to 17 per cent. zinc. He had intended to give the impression in his Paper that the brasses used in Great Britain ranged in copper content between approximate limits of 55 and 80 per cent. Almost every manufacturer or specifying engineer selected a different composition to which founders had to comply. He had mentioned in particular the 75 per cent. copper, 25 per cent. zinc alloy and the 60 per cent. copper, 2 per cent. lead, 38 per cent. zinc alloy because he had thought that these were typical and very logical compositions.

There would not be a great difference in the properties of the binary copper-zinc alloys in which the zinc content varied from 15 per cent. to 25 per cent. Naturally, alloys having the lower zinc content would be slightly weaker and softer, while, in respect of electrical conductivity, he suggested that the difference would be between about 25 per cent. and a little over 30 per cent.

Degasification of Copper

PROFESSOR PORTEVIN, dealing with the author's statement concerning the *rôle* played by gas in the reactions, particularly on the elimination of hydrogen and oxygen, and the point made that hydrogen could be eliminated by a process described in an American Patent, said he was not well acquainted with the Patent as distinct from other technical literature, because it was sometimes rather difficult to interpret; he was aware of only one process for removing the hydrogen from alloys of the kind discussed, and that process depended on the use of oxygen to remove the hydrogen. He asked for further information on the matter.

With regard to the suggestion that aluminium was a good deoxidiser, he expressed the opinion that it was difficult to deoxidise satisfactorily by the use of aluminium. From experiments actually carried out by Dr. Bastien, who was present, it was found that when aluminium was added to highly oxidised copper, the little drops of melted aluminium surrounded themselves with an oxide film which precluded deoxidation; it was necessary to stir the melted metal vigorously, preferably with a flux dissolving the oxide on formation.

Mr. Miller's Reply

MR. MILLER replied that the Patents to which he had referred were taken out by the American Metal Company or their subsidiaries, and there was no doubt that with the aid of those Patents the company had been able to produce and market oxygen-free copper which in the cast condition was extremely sound, free from oxygen, and was of high conductivity. According to descriptions given in the Patents and by E. F. Cone,* production involved the melting of cathode copper in a reverberatory furnace, the molten metal then being led into a subsidiary furnace sealed from the ordinary atmosphere. In this, charcoal, which functioned as a cover and a filter, reduced the oxide; in addition there was provided an atmosphere of carbon dioxide and nitrogen from which there was careful removal of water vapour. The metal was led by closed launders into the moulds, which were also filled with carbon monoxide and nitrogen, so that solidification occurred out of contact with air. It was presumed that the hydrogen was removed by a purging action of the non-reactive gases.

As to the use of aluminium as a deoxidant, he said he had not had actual experience of its use in very small quantities. Such Papers as he had read rather deprecated its use for this purpose, since it formed aluminium oxide films, which became entrapped in the metal and gave rise to defects of a very serious nature. On introducing aluminium into copper he could quite visualise the immediate formation of a film which would prevent the remainder of the aluminium from functioning satisfactorily.

Export of War Material

SUSPENSION OF LICENCES

The Board of Trade on August 23 made an order suspending until after October 1, 1939, the validity of outstanding export licences for war material for foreign countries. The order states that it is desirable in the interests of Imperial security that all licences (with certain exceptions) hitherto granted by the Board of Trade for the export of goods should be reviewed and for that purpose their validity is forthwith suspended.

This order has been made to enable the outstanding licences to be reviewed; but it is not the intention that all exports should be prohibited; exporters holding licences who wish to ship during the period of the suspension are therefore at liberty to apply to the Board of Trade (Imports and Exports Licensing Section) to have the suspension of a particular licence cancelled. To avoid delay, the application should, if possible, be accompanied by the outstanding licence and in any case the number of the licence should be quoted.

The Board of Trade also announce that in order to conserve stocks in this country at the present time arrangements are being made to prohibit forthwith the export to foreign countries, except under licence, of certain commodities, some of which are specified below. Any communication on the subject should be sent to the Export Licensing Department, Board of Trade, 80-82, Pall Mall, London, S.W.1.

List of Materials

Aluminium and alloys containing aluminium.—Ingots, blocks, slabs, billets, notch bars, wire bars, cakes and granules.

Antimony and alloys containing antimony.—Ingots, blocks, slabs, billets, notch bars, wire bars, cakes and granules.

Bismuth metal; cobalt, metallic; copper, unwrought; lead, unwrought; mercury; nickel (including unrefined nickel and matte) and alloys containing nickel, unwrought.

Palladium, iridium, rhodium, osmium, ruthenium, osmiridium, beryllium and columbium (niobium), and alloys thereof. Platinum and alloys thereof, in grain, ingot, bar or powder.

Ferro-alloys of all descriptions; silicon and alloys thereof and silicon powder; tin in blocks, ingots, bars and slabs; zinc or spelter, unwrought; nonferrous scrap and old metal; iron and steel scrap and waste; also motor spirit, gas oil, toluol and toluene, rubber and rubber scrap.

* "Metals and Alloys," 1937, 8, 3.

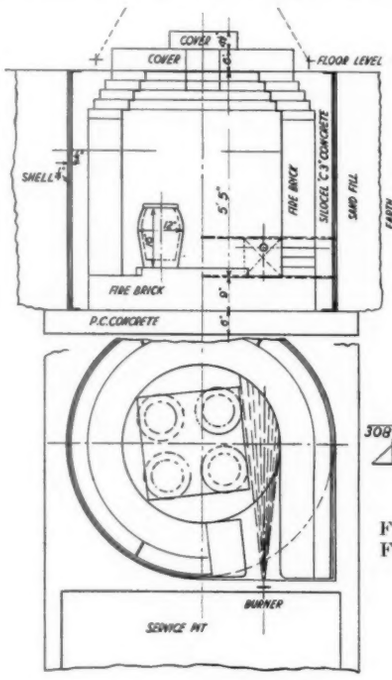
A Melting Furnace for Ferro-Manganese

By E. G. FIEGEHEN, M.I.Mech.E.

In preparing to pour moulds for manganese-steel castings, the necessary ferro-manganese is often melted separately in plumbago crucibles and added to the ladle of open-hearth or Bessemer steel in the correct proportion, by weight, to give the analysis required in the castings.

The melting furnace illustrated by Fig. 1 is designed for melting 400 lbs. of ferro-manganese in four plumbago crucibles, each holding about 100 lbs. of the alloy and weighing, empty, 45 lbs.

It will be assumed that the furnace is oil-fired, a heavy fuel oil being used of about 0.95 specific gravity (say 17 deg. Beaumé) and containing less than the specified maximum of sulphur (say less than 0.5 per cent.). The furnace could equally well be fired by gas, and either arrangement makes a convenient and economical unit, preferable in every way to the open-top coke furnaces formerly used and resulting in a longer life of expensive crucibles.



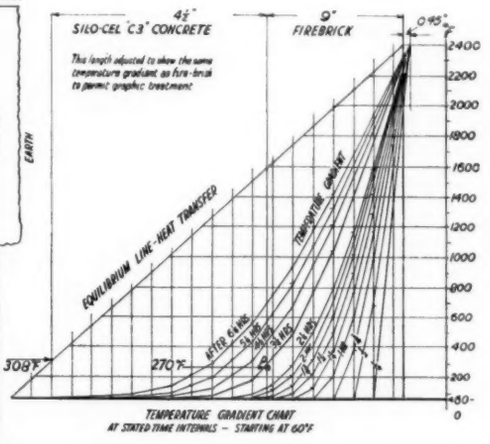


Fig. 1 (Left).—Plan and Elevation of Furnace.
Fig. 2 (Above).—Temperature Gradient Chart.

Data

The melting point of ferro-manganese may be taken at 1,200 deg. C. and the furnace will be heated to, say, 1,315 deg. C. to provide a suitable superheat. The time required to melt the charge depends upon the rate at which oil is burned in the furnace, and practical considerations demand that the rate of heating should not be too high.

Further, each pound of oil burned per hour requires for its proper combustion a minimum volume in the furnace; this corresponds approximately to 40,000 B.T.U. released per cub. ft. of furnace volume per hour.

It is clear, from the drawing, that the weight of brickwork to be heated far exceeds the weight of the charge, and it is manifestly desirable to keep the demand for combustion volume at a reasonable figure in order that this disparity in weight shall not become too great.

A melting time of 3 hrs. is envisaged, for this will result in reasonable proportions of the furnace, and is found quite suitable for foundry requirements.

Heat Demand

In what follows, it will be assumed that the specific heat of ferro-manganese is 0.12 and that its latent heat of fusion is 6,600 B.T.U. per lb. The specific heat of graphite will be taken at 0.20 and of firebrick (at 1,335 deg. Fah. or 724 deg. C.) 0.24.

Before one can estimate the required heat input one has to make a reasonable estimate of the average temperature of the firebrick lining after a run of 3 hours from cold (at 15 deg. C.), so as to calculate the heat absorbed by it. Fig. 2 shows the approximate thermal conditions in the firebrick lining and insulation after elapsed times, from cold, indicated upon the curves.

The lining, in the present case, consists of 9 in. of first-class firebrick backed by 4½ in. of Sil-o-Cel "C3" insulating concrete.

The point P on this diagram indicates the probable temperature at the back of the firebrick lining at the end of the first 3 hrs. run (say 270 deg. Fah. or 132 deg. C.).

The inner face of the lining being at 2,400 deg. Fah. (1,315 deg. C.), it may be assumed that the average temperature is 1,335 deg. Fah. (725 deg. C.), a temperature rise of 1,275 deg. Fah. from cold. The total heat demand of the furnace for a 3-hr. run, starting at 60 deg. Fah., will therefore be:—

	B.T.U.
For 400 lbs. of ferro-manganese:—	
Sensible heat – 400 × 0.12 × 2,340 =	112,000
Latent heat of fusion – 400 × 6,600 =	2,640,000
For four 45-lb. graphite crucibles:—	
Sensible heat – 4 × 45 × 0.20 × 2,340 =	84,000
For the firebrick shell (weighing 8,980 lbs.):—	
Sensible heat – 8,980 × 0.24 × 1,275 =	2,750,000
Total heat input for 3 hrs.	5,586,000

The heat demand, per hr., will be 5,586,000 ÷ 3 = 1,862,000 B.T.U.

Assuming a thermal efficiency of 30 per cent. for this furnace, and a lower calorific value of 18,500 B.T.U. per lb. of oil,

$$\text{Pounds of oil per hour} = \frac{1,862,000}{18,500 \times 0.30} = 337 \text{ lbs.}$$

or 33.7 Imperial galls. of oil per hr.

Combustion Volume

Sufficient space has to be provided for the combustion of this amount of oil per hr. in the furnace, without exceeding a heat release of more than, say, 40,000 B.T.U. per cub. ft. per hr.

Then the combustion volume required

$$= \frac{1,862,000}{40,000} = 46.5 \text{ cub. ft.}$$

Referring to Fig. 1, it will be found that the gross volume of the furnace, less the volume occupied by the crucibles, is 44.5 cub. ft. It should be pointed out, at this stage, that the heat demand, and consequently the weight of oil consumed per hr. will be less upon succeeding runs of the furnace than on the first run, starting from cold, as has been assumed.

This type of furnace, when shut down after a run, with the covers in place, retains a large amount of its heat for days. In such intervals, its equalisation of the heat in the lining is going on and when re-started the average temperature of the brickwork is likely to be appreciably higher than we have assumed it to be at the end of the first 3 hours' run.

Combustion Gases

The weight of combustion gases produced by the burning of 1 lb. of oil with 40 per cent. excess air may be taken at 20.44 lbs. Measured at the exit temperature of 2,400 deg. Fah. (1,315 deg. C.) this weight of gas measures

$$\frac{20.44 \times 13.3 \times 2,860}{520} = 1,495 \text{ cub. ft.}$$

Therefore the gases from 337 lbs. of oil burned per hour will pass the 10-in. diameter opening provided in the main cover at a velocity of

$$\frac{337 \times 1,495}{3,600 \times 0.78 \times 0.83^2} = 25.8 \text{ ft. per sec.}$$

which corresponds to good practice.

The air required for the combustion of 1 lb. of oil weighs 19.47 lbs. The bulk of this enters through the 9-in. by 10-in. opening opposite the burner and will thus have a velocity of

$$\frac{337 \times 19.47 \times 13.3 \times 144}{3,600 \times 9 \times 10} = 38.7 \text{ ft. per sec.}$$

The draught required to produce this velocity is:—

$$\frac{0.188 \times 38.7^2}{520} = 0.34 \text{ in. of water.}$$

The upward convection current in the furnace plus the inductive action of the jet from the burner will provide adequate draught.

Furnace Construction

Referring to the detailed construction of this furnace, it will be seen to consist of a ¼-in. steel plate shell, resting upon a light slab of Portland cement concrete. A hole, in a dry location, is dug in the foundry floor, deep enough to bring the top of the furnace flush with the floor level, which is convenient for handling the crucibles with tongs.

The concrete base is then poured at the bottom of the excavation and, when this has set, the plate shell is placed in position and its interior is lined with corrugated cardboard sheets, pasted in position, for the purpose of providing expansion space for the lining. The firebrick base and shell are then built up, including the formation of an inlet for the flame, as shown in the sectional view.

To support this portion of the lining, a strip of the shell plate is cut and bent back and covered top and bottom by closing-plates welded to it.

It will be seen that the group of crucibles is located to the left of the centre line of the furnace and slightly skewed, to escape the direct impingement of the burner flame. They are supported upon a raised rectangular platform, thus leaving a space to receive possible spills, which can be removed through the burner opening.

In front of the burner opening a brick-lined service pit is constructed, provided with steps and covered by checker plate with a hinged access door.

(*Concluded on page* 156.)

Work of the Technical Committee of the Institute of British Foundrymen*

By J. W. GARDOM†

It was to the International Foundry Congress held in London in 1929 that the first technical report of the Institute of British Foundrymen was presented, and it is thought, therefore, that a general review of the work which the Technical Committee has done during the intervening years may be of interest. To those who are members of the Institute of British Foundrymen, such a review will serve as a progress report, but even to those outside, and particularly those engaged in the industry abroad, this Paper should be of interest, for it reflects to a large extent the progress which has been made in the industry which this Institute seeks to serve.

Although a Test Bar Committee had been in existence for several years prior to 1930, it was not until April 12 of that year that the Council of the Institute sanctioned the formation of the Technical Committee.

The Technical Committee is composed of a Convener, a Deputy Convener, and at the present time 62 members, and several corresponding members. All these gentlemen are engaged in the industry, and on election to the Technical Committee serve on a sub-committee dealing with the subject in which they have specialised. The work which they do on behalf of the Institute is entirely voluntary, and through the courtesy of the firms with whose works they are associated, many members of the Committee are able to carry out work of an investigational character.

The Institute has under its control no metallurgical laboratories, and this is one of the major reasons why primary research is not undertaken. When any research connected with the Committee's work cannot be satisfactorily carried out by individual members, the co-operation of one of the research associations is sought. These associations, such as the British Cast Iron Research Association and the British Non-Ferrous Metals Research Association, not only specialise in fundamental research, but have in the past co-operated with the Institute in any such work which it desired to undertake.

Meetings of the full Technical Committee are held at least four times per annum, and meetings of individual sub-committees may be called whenever they are required. These sub-committees were appointed by the Technical Committee to deal with cast iron, malleable cast iron, non-ferrous metals and sands and refractories, and to investigate problems in these specific fields. At a later date the Sands and Refractories Sub-Committee was divided into two, namely, the Sands Sub-Committee and the Refractories Sub-Committee, and in addition a Melting Furnaces Sub-Committee and a Costing Sub-Committee were appointed. Since the forerunner of this Committee had devoted its attention to the formulation of specifications and the work of standardisation, it was only to be expected that these subjects should also form the basis of procedure which the Technical Committee should adopt. This, in fact, was the case, and each of the Sub-Committees proceeded to obtain as many specifications covering their particular aspect of foundry practice as was possible. The Non-Ferrous Sub-Committee eventually accumulated 67 specifications, covering 47 different alloys, whilst the Steel Castings Sub-Committee collected 21 different specifications for plain carbon steel castings for various purposes.

Naturally, this information had to remain confidential to the members of the Technical Committee, but as a result of the close study which members made of these specifications, each Sub-Committee was able to decide upon a programme of work. In this standardisation of practice and specifications covering all branches of the foundry industry, the results of works' experience is, of course, essential.

The Institute, mainly through members of the Technical Committee, is represented on various committees of the British Standards Institution which deal with foundry subjects, and in this way the Institute is able to safeguard the founders' interests when new specifications are being drafted, or when revisions are being made to existing specifications. Owing also to the organisation of the British Standards Institution, the Technical Committee is able to examine the drafts of any new or revised specifications dealing with foundry subjects and to make recommendations to the appropriate British Standards Institution Committee when such new drafts have, in the opinion of the Technical Committee, not been drawn up in accordance with the best foundry practice, or with due regard to the founders' viewpoint.

Another factor which arose from the examination of the various specifications was that it was found possible to reduce the number of specifications and use British Standard Specifications in their stead. In the cast-iron, steel, malleable cast-iron and non-ferrous sections of the industry, this was found to be possible to quite an appreciable extent, and largely as a result of the Committee's recommendations, several private specifications were either replaced by British Standard Specifications, or the British Standard Specifications were quoted as alternatives.

The Technical Committee is keenly sensible of the work which is carried out in other countries, and, where it is desirable or necessary, the Committee co-operates with the foundry technical associations abroad. A particularly interesting example of the progress in this sphere is the work which the Cast Iron Sub-Committee is doing in conjunction with the International Committee on Testing Cast Iron. It is hoped that through Mr. J. E. Hurst, who is a prominent member of the Cast Iron Sub-Committee, and President of the International Committee on Testing Cast Iron, further useful work will be done in this direction.

THE REPORTS OF THE TECHNICAL COMMITTEE

Cast-Iron Sub-Committee

After its first year of work, in which a collection and examination was made of specifications for grey cast iron, the Cast Iron Sub-Committe was enlarged and it was decided that it could best assist the industry by pursuing investigations in the following four directions:—

(1) To investigate the theory that the properties of cast iron in relation to strength and soundness were at their worst when the phosphorus content was approximately 0.4 to 0.6 per cent.

(2) To compile a series of photomicrographs representative of various grades of cast iron, which might be used as a reference standard by metallurgists in the industry.

(3) To attempt to evolve rules for the contraction of cast iron, according to composition, section and pouring temperatures.

(4) To examine existing methods of wear testing, with a view to recommending a standard form of test.

All these subjects were investigated, and the Sub-Committee's results were published in the form of a report in 1934[1], and in a Paper by Neath.[2] Various members of the Committee were also, at that time, engaged upon researches connected with these investigations, and through their kind co-operation, the Sub-Committee was enabled to study those results which were of interest to them.[3, 4]

The work of compiling a series of standard photomicrographs was satisfactorily completed in conjunction with the British Cast Iron Research Association, and the complete series has been published,[5] and includes microstructures of both blackheart and whiteheart malleable cast iron.

Before the work on the foregoing subjects had been completed, the Sub-Committee had prepared an internal report on the physical properties of cast iron. This was not published generally, but made available only to members of the Institute. However, the majority of the data presented is now included in the Sub-Committee's latest report and will be made generally available in the near future. It has already been presented before several Branches of the Institute, and a report of the discussions will also be published, together with the Cast Iron Sub-Committee's reply.

It was largely as a result of the Sub-Committee's work on the various properties of grey and high-duty cast iron that it was decided to seek a revision of British Standard Specification 321/1928, which they felt to be somewhat out of date, as a result of technical progress in the industry. In order to obtain such a revision, further work had to be completed so that the Institute's representatives on the British Standards Institution's Committee could be supplied with relative data. In due course, the revision of this specification was completed, and a new specification, No. 786, covering high-duty cast iron was issued. After this the Sub-Committee prepared and published its second report.[6] The Sub-Committee is now continuing its work by investigating the relationship between various mechanical tests.

The question of the classification of graphite has also been considered by the Sub-Committee, but unfortunately it has been found necessary to abandon this investigation owing to the lack of facilities for the extensive research that it was found to involve. The Sub-Committee appreciates the need for the continuance of this work, and owing to the character of the investigational work necessary, has suggested that this problem might be taken up by the British Cast Iron Research Association.

Steel Castings Sub-Committee

When first the Steel Castings Sub-Committee started on its work of collecting and comparing existing specifications for steel castings, it was found that in this country there was but little deviation in the requirements of the various issuing houses, and that in general they all conformed quite closely to British Standard Specifications already existing. Little further could, therefore, be done with the exception of recommending that those specifications which showed any wide divergence from the British Standard Secifications should be revised to conform more closely with standard practice. In several cases such recommendations met with success.

At a somewhat later date, the Steel Castings Sub-Committee turned its attention to four main problems:—

(1) Impact testing of steel castings.

(2) The heat-treatment of carbon steel castings.

(3) The soundness of steel valve castings.

(4) Fluidity (flowing power) of molten steel.

A considerable amount of data has been collected from industry in connection with all four of these investigations, and it is expected that three reports will be issued in the very near future.

Particularly interesting are the data on the

* Report presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.
† Convener, Technical Committee of the Institute of British Foundrymen.

heat-treatment of carbon steel castings, for the information presented will cover typical British practice, and it is hoped that this Report will show where improvements may be possible. The Izod impact test results show remarkable variations in all classes of steels on which these tests were made.

For the third investigation, some twelve valve castings were made and subjected to severe testing before cutting for examination.

The Steel Castings Sub-Committee has also played a not unimportant part in investigations carried out under the auspices of other investigators and institutions, particularly the Iron and Steel Institute, on whose Steel Castings Research Committee the Institute is represented. It was, in fact, in a report of the Iron and Steel Institute[7] that the data which the Steel Castings Sub-Committee had collected on fluidity (flowing power) was published.

Non-Ferrous Sub-Committee

With the extended use of aluminium, magnesium and nickel in non-ferrous foundries to-day, an enormous range of commercial alloys has been developed. Very often, only very slight modifications in composition are evident in the different alloys, each of which is deemed by its proprietors to have some property which makes it far more useful than other similar alloys. With this ever-growing complexity, the work of this Sub-Committee has been particularly difficult. In order to simplify its programme to a large extent, the Non-Ferrous Sub-Committee has, so far, concentrated upon the heavier types of non-ferrous alloys.

Its first work was to examine the various specifications which had been drawn up for the different alloys, and it was as a result of this work that it was decided to simplify the position by standardising upon a smaller number of alloy compositions. In a large measure, the work has been successful, and negotiations are now in hand with the British Standards Institution for the preparation of specifications for two leaded gunmetals, which formed the subject of a Report issued by the Sub-Committee in 1936.[8] This Report made a serious endeavour to bring about some standardisation of composition in the alloys commonly used, and led to the preparation of a further report, which is being presented to this Congress,[9] on the properties of three leaded phosphor bronzes.

This work now being complete for the time being, the Sub-Committee has turned its attention to the degasification and deoxidation of non-ferrous alloys, and is at present engaged upon the preparation of a report on this subject.

Malleable Cast Iron Sub-Committee

The Malleable Cast Iron Sub-Committee has, during the whole period of its existence, devoted its attention to an examination of the British Standard Specifications Nos. 309 and 310, 1937, for whiteheart and blackheart malleable cast iron, and it is believed that when a report of this work is published, it will form one of the most authoritative statements which have been made concerning malleable cast iron.

Already two interim reports[10,11] have been published upon the Sub-Committee's work, which, although of considerable interest, have, it is thought, not received the attention which they deserve. The second of these reports dealt with dimensional tolerances for castings—a subject which was inadequately covered in all existing specifications, not only for malleable cast iron, but also for grey cast iron, steel and non-ferrous alloys. That a report dealing with a question of such vital importance to the foundry industry as a whole should have received so little attention has astonished the Technical Committee, especially as this Report, together with an investigation carried out by the American Foundrymen's Association on grey cast iron, forms probably the only recent work upon this subject.

A suggestion that a yield point : tensile strength ratio should be included in the malleable specification has received the consideration of the Sub-Committee. A considerable amount of data has been collected on this subject, and the present views of the Committee are tending against the inclusion of such a ratio in the specification. Experimental data have shown that the yield point : tensile strength ratio varies considerably, and in many cases high results are obtained on imperfectly annealed material. Under such conditions, such a ratio would be of no service to the inspecting engineer, who wishes to ascertain whether the material has undergone correct annealing treatment.

In this country, literature upon the subject of malleable cast iron is particularly scarce, whilst in the United States of America there is not only considerably more literature, but also the product is receiving ever-increasing attention. Government departments, motor-vehicle manufacturers and other potential users in this country seem often to overlook the possibilities of malleable cast iron. This has been attributed largely to the existing specifications, which, being over a decade old, do not now faithfully reflect the position in the industry to-day. In spite of the seemingly undeveloped state of the industry, the Technical Committee is aware that considerable improvements have been made in practice during the past few years, and it is thought that the work which the Malleable Cast Iron Sub-Committee is doing will materially assist in the development of the malleable cast-iron industry in this country.

Sands Sub-Committee

Methods of testing dry sand, green sand and loam have occupied the attention of this Sub-Committee during the past few years. As is well known, this subject is one which has assumed great importance in recent times, particularly since the mechanisation of foundries has been accelerated.

Two main sand-testing methods were in existence at the time the Sands Sub-Committee began its work, namely, those recommended by the American Foundrymen's Association, and the British Cast Iron Research Association's methods. Members of this Sub-Committee were of the opinion that neither of these methods was in itself the ideal one, and they considered that a useful purpose would be served by examining and comparing the procedures and apparatus recommended by these two Associations.

The work was very carefully carried out, and in 1933 a report on "Routine Methods for Testing Green Sands" was presented to an Annual Conference of the Institute.[12] The publication of this Report was followed by an investigation into the testing of dry sand and loam, and a report on this subject has now been published.[13]

The subject of sand testing has not yet been exhausted and the Sub-Committee realises that a considerable amount of work has yet to be done. The Sub-Committee feel, however, "that next in importance to investigating and recommending simple and satisfactory methods of testing sands, is the need for a campaign to urge upon founders the benefits which they will obtain by systematically using such tests daily in the foundry." Their contribution to this campaign has been the preparation of these reports, which have aroused considerable interest in the industry.

At the present time the Sub-Committee is engaged upon the following lines of investigation, and is surveying the sand mixtures as used at the present time in Great Britain for various classes of castings.

(1) Casting defects attributable to moulding materials.

(2) Drying ovens: (*a*) for dry sands, and (*b*) for oil sands.

(3) Testing oil sands, including the grading and sampling of silica sands.

(4) The compression-strength testing machine and the measurement of deformation of moulding sands.

The first of these is proving to be a most interesting study, and to assist the Sub-Committee in its work the co-operation of industry has been sought with a view to obtaining samples of castings, defects in which may be attributable to the moulding material used. The second investigation will, it is expected, result in a report being issued upon various drying stoves and practices which are in common use to-day, whilst the third study will assist in the completion of the Sub-Committee's work on recommended methods for testing various sands.

It is realised that the values obtained under the heading of green compression strength are of great importance in evaluating a moulding sand. It is, however, appreciated that when this strength is at its maximum the sand is brittle and unsuitable for moulding. Other qualities of the sand must be taken into consideration in association with the green compression strength in determining the sand's suitability in practice. One of the factors is a capacity to deform under load, and methods of measuring it are under consideration by the Sands Sub-Committee.

Mention should be made of the Joint Committee on Sands which has recently been set up in this country. On the Committee are representatives of the British Non-Ferrous Metals Research Association, the Iron and Steel Institute, the British Cast Iron Research Association and the Institute of British Foundrymen.

The aim of this Committee is to produce an agreed statement on routine methods of testing, to be adopted as standard, and recommended to the industry. This necessitates the most careful scrutiny and consideration of all present methods and testing apparatus, and although the work is not complete, considerable progress has already been made.

Melting Furnaces Sub-Committee

Formed at a later date than the majority of the other sub-committees, the Melting Furnaces Sub-Committee was appointed with the primary object of preparing a report upon cupola melting practice. This work has, however, been extended to cover all types of melting furnaces for cast iron. A most thorough and comprehensive treatise has now been drawn up and will be published within the next few weeks.[14]

No pretension is made that this Report contains any really original matter; its value lies rather in its completeness, for not only does it cover the design and operation of cupolas, electric furnaces and various types of rotary and crucible furnaces, but there is also a section dealing with melting costs. It will, therefore, be seen that it will be an invaluable document for students, and all those who wish to make a study of the fundamentals of this phase of foundry work. A serious endeavour has been made throughout this Report to include some reference to every well-founded opinion which has been expressed upon any of the furnaces dealt with in its pages.

Refractories Sub-Committee

As has already been mentioned, the Refractories and Sands Sub-Committee was divided in 1936 into two—the Sands Sub-Committee and the Refractories Sub-Committee. The work of this comparatively new Sub-Committee on refractories has necessarily been slow, for after its initial work of drafting a specification for cupola firebricks, it has been necessary to test the recommended material in practice before any definite recommendation can be made to a standardising body. Meanwhile, preliminary tests of a practical nature have been carried out with a view to preparing a similar draft specification for cupola ganister. It is expected that a comprehensive report will shortly be published giving details of these investigations.

In furtherance of this work, the Convener of the Sub-Committee has presented many valuable Papers before several Branches of the Institute, and also to foundry associations abroad.

Costing Sub-Committee

The Costing Sub-Committee, like the Melting Furnaces Sub-Committee, was also appointed to carry out a specific piece of work, and in this case to try to make definite recommendations on costing systems suitable for the foundry.

As is well known, there are few subjects in which the foundryman is more interested, and similarly there are but few phases of foundry work which are so beset with intricate problems, each of which has been dealt with by many well-known authorities. It is interesting to mention that considerable discussion took place amongst members of the Sub-Committee and officials of the Institute, as to whether the question of costing came within the scope of the Technical Committee, or even of the Institute.

Eventually, it was agreed that the Costing Sub-Committee should be formed. Its Report[13] is probably the most complete which has been published on this subject, at least in this country, and its value to industry can be gauged from the number of large and important foundry companies who have installed the system outlined therein. Naturally enough, considerable comment and discussion took place upon this report when it was presented to the 1936 Annual Conference of the Institute, before Branches and also before other associations, but it is significant to note that none of the contributions to the discussions necessitated any alteration being made to the recommendations.

The work completed, *pro tempore*, the Sub-Committee was dissolved in 1938, but if at any time there arises the necessity of continuing its work upon this subject, the Costing Sub-Committee will be reconvened.

Conclusion

In this report, an endeavour has been made to present, in a small space, a picture of the work which the Technical Committee has so far carried out, and it is hoped that, at least to the members of the Institute of British Foundrymen, this will prove of interest and value.

In some stages of the Technical Committee's work, it may be thought that progress has been comparatively slow, but it must be remembered that all the reports which have been mentioned have been prepared by men engaged in industry. The members of the Technical Committee are conscious that progress in some spheres has not been made as rapidly as could be wished, and a review has therefore recently been made of the Committee's work. As a result of this, and because of recent reorganisations in the Institute's working methods, it is believed that in future the Technical Committee will prove of even greater value to members of the Institute of British Foundrymen, and others engaged in the foundry industry.

The author wishes to express his thanks to Mr. J. Bolton, Assistant Secretary of the Institute of British Foundrymen, for his help in the preparation of this report.

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Factory Lighting and A.R.P.

FINANCIAL ASSISTANCE FOR COST OF OBSCURATION

A considerable number of employers are still uncertain regarding arrangements they are expected to make for the obscuration of lighting, and the financial allowances they are entitled to for so doing, in connection with A.R.P.

A semi-official announcement points out that briefly the position is that in factories and other establishments, where shuttering is provided under compulsion, following the serving of a notice, financial assistance will be given as provided under Section 13 of the Ministry of Supply Act. Where it is installed voluntarily, without official advice, it comes under the provisions of a statement made by the Chancellor of the Exchequer, who pointed out earlier in the year that, in general, certain expenditure in connection with air-raid precautions would be admissible as a deduction in computing trading profits for income tax purposes. Some items coming under this heading include the provision of dark blinds, screens, and paint, to render windows opaque. No deduction would be allowable in respect of expenditure of a capital nature on air-raid precautions; for example, expenditure which results in the physical alteration of, or the incorporation of additions to, the structure of premises; but the Board of Inland Revenue would not be disposed to regard as within this category expenditure on items such as steel shutters for protection of windows. Glass may be rendered opaque by paint, or by the provision of screens; but if it should be shattered by bomb explosion, the value of screening by paint and probably by blinds would disappear, and the lighting of the factory would be unscreened. Also, if roof glass were destroyed, the interior of the factory would be exposed to the weather and possibly work could not continue. Many firms will therefore doubtless provide some form of shuttering. The provision of "weather-proof" shuttering is obligatory only on firms engaged upon work of vital importance, which does not permit of such interruption of production, as would be caused if a factory ceased to be weather- or light-proof due to glass being shattered.

With the approval of the Lord Privy Seal and of the Minister of Supply, it has been decided that the requirement of such "weather-proof" obscuration shall be treated as a requirement under Section 13 of the Ministry of Supply Act. This means that it will only be required in cases where notice is served, and expenditure in such cases will be financially assisted in accordance with the terms of the Ministry of Supply Act. In some cases industrial establishments may have to arrange for a matt surface on the external side of glass roofs, so as to avoid reflection which would be a guide to hostile aircraft. Certain of them have been advised that it will be necessary to provide such a matt surface. The Lord Privy Seal is prepared to regard this aspect of the problem of lighting as allied with camouflage. Only those establishments upon which notice is served will therefore be required to undertake this work, and they will receive grant in respect of the cost in accordance with the terms of Section 46 of the Civil Defence Act. The work will therefore be treated as if it were for the purposes of camouflage, and will receive a grant not exceeding one-half of the cost involved.

Preparatory Measures for Concealing Lighting

In view of the international political situation, the Lord Privy Seal has announced that the Government consider it desirable that preparations should now be made to comply with the lighting restrictions which may have to be imposed at short notice should an emergency arise.

Occupiers of industrial premises are reminded that they must make preparations to obscure lighting. These should be on the lines suggested in the Home Office pamphlet on lighting restrictions for industrial and commercial premises. Where the necessary material for permanent screening is not available, occupiers must consider what methods of improvised screening can be applied at short notice. They must also make preparations for the extinction of all external lighting, except external lighting required for the conduct of work of vital national importance. In such cases the lighting must be reduced to the minimum required for working purposes, must be screened so as not to be directly visible from the air, and must be capable of instant extinction.

In the case of works where processes are carried on involving the emission of glare or flames—*e.g.*, iron and steel works, glass works, potteries, etc.—all possible preparation should be made to ensure that the flames or glare can be obscured so far as is possible. In the case of burning pit-heaps, preparation should be made to deal with the heap so that no flames are visible.

It will be appreciated that unless the necessary preparations are made to obscure lighting it will be necessary, in the event of an emergency, to require that no artificial lighting is used until action has been taken to comply with the Lighting Order.

A Melting Furnace for Ferro-Manganese

(*Concluded from page* 153.)

The space between the circular plate shell and the completed firebrick lining is now filled with Sil-o-Cel "C3" insulating concrete or similar material. Firebrick expands appreciably when heated to furnace temperature and, to permit of free expansion, it is advisable to split the ring of insulating concrete, say into six segments as indicated, by the introduction of thin vertical strips of wood, between the outer shell and the firebrick, before placing the insulating concrete.

It will be seen that the inside diameter of the firebrick lining is reduced, at the top, to a diameter sufficient to allow the easy manipulation of the crucibles with tongs. This opening is closed by a rectangular cover of firebricks, secured in the usual way by bolted forged clamps and provided with shackles and chains for removal. The central hole in this cover is closed, when the furnace is out of service, by a small clamped cover, which can also serve as a damper on occasion. The space between the excavated hole and the outside of the shell plate is now filled with dry foundry sand.

The oil burner can be of any suitable (and preferably simple) type, having a capacity of, say, 35 gallons per hour. The atomising air should be heated to, say, 500 deg. Fah. (260 deg. C.), and the oil to 180 deg. Fah. (82 deg. C.). The flame from the burner, being directed tangentially into the shell, sweeps the interior in an ascending spiral conducive to good combustion conditions.

Thermal Storage

It has so far been assumed that the furnace is to be heated from a cold start, for, thermally, this is the least favourable condition. If more than one run is required during the 24 hours, as will generally be the case in a busy department, especially when making high-manganese (13 per cent.) steel, the second and following runs will start with the substantial advantage of a hot furnace and will use less oil for melting the charge during the 3 hours' duration of each run.

The radiation from the exterior of this type of buried furnace is much less than if it had been built entirely above floor level and exposed to cooling air currents. It will be seen by reference to Fig. 2 that, after the first 3 hours run, the outside of the shell of C3 concrete has not commenced to rise above 60 deg. Fah. The chart gives a useful idea of the passage of heat through the firebrick and insulation, and of the significance of elapsed time on the slope of the temperature gradient, and consequently of the heat stored in the lining.

IT IS UNDERSTOOD that orders for textile machinery, valued at £100,000, have been placed in Lancashire recently by Mr. D. T. M. Davies, chairman and managing director of Davies Coop & Company, cotton manufacturers, of Melbourne, Australia. It is believed that the machinery purchased represents only a part of the contracts that will eventually be placed for the equipment of new factories in the Commonwealth.

ably the only recent work upon this subject.

A suggestion that a yield point: tensile strength

chine and the measurement of deformation of moulding sands.

Papers before several Branches of the Institute, and also to foundry associations abroad.

General Principles Applicable to the Compounding of Alloys by Melting*

By Professor ALBERT PORTEVIN

(Presented on behalf of the Association Technique de Fonderie de France)

By accepting the invitation to present a Paper on behalf of the Association Technique de Fonderie, there was the obligation imposed to deal with the general subject recommended by the International Committee of Foundry Technical Associations, since it was the French delegation which suggested it. The subject is of outstanding interest because of its fundamental importance to founding and also because it has not so far been to the author's knowledge the object of a general discussion. The only general conceptions of the subject that are available in French technical literature are those to be found in the lecture courses given to the students of the Paris Foundry School and are, therefore, only available to a very limited public.[1] Moreover, this scarcity of information is a difficulty which adds to those resulting from a study of the subject. Thus, the matter presented must perforce be in the nature of a lesson, and because of this a request is made in advance for sympathetic consideration if there should be incorporated any lapses or inexactitudes in what is a general didactic *exposé*, which the author has developed in a somewhat novel form. The subject will be covered where possible by examples, and especially by general rules, whilst risking the non-applicability of premature generalisations in particular cases.

PART I.—THE PROBLEM STATED

The problem to analyse and solve can be postulated as follows:—

Being given raw metallic materials currently available and particularly industrial metals, the problem is to produce economically a liquid homogeneous alloy, ready for casting, without changes acting adversely against the useful properties of the casting.

Under this very condensed form this hypothesis calls for some additional explanations. "Economically" implies melting losses of the lowest possible order, but at the same time without having recourse to irksome melting processes in relation to the price of the alloy and its usages. Thus, for cast iron, recourse will usually be made to the cupola, an economic method of melting only used at the moment in quite rare cases in connection with copper alloys. This also implies, from the cost price point of view, that *the foundry scrap should be re-used;* that is to say, re-enter into later furnace charges, so as to ensure continuous production. This condition stresses and defines the phrase "without acting adversely against," for by repeated meltings the alterations to the bath are accumulative and become progressively noticeable by repetition.

"*Liquid Alloys.*"—Processes for making alloys by electrolysis, cementation, compression or reaction in the solid state can naturally be excluded, as also can those carried out for the object of making master alloys or "additions." "*Changes acting adversely*" can, moreover, be widened to embrace various points of view, such as *chemical change* modifying the specific properties of the cast metal or the soundness (depending upon physical defects) of the actual casting or physical change through *modification of the solidification crystallisation.* These changes are extremely diverse according to the alloy and the melting conditions. The limits of tolerable change are above all variable with the alloy, the type of change and its use.

"Ready for casting" implies that the liquid alloy is at the requisite temperature and has *the chemical composition within the specified limits,* such limits being variable with the alloy and being different, for example, in the cases of coinage and anti-friction alloys. This equally implies that the alloy is adequately protected against the changes occurring during casting.

The solution of this problem is therefore dependent on the two following fundamental factors:—(A) Raw materials; and (B) melting conditions. These must be briefly examined for a proper understanding of the problem.

PART II.—FACTORS IN THE PROBLEM

(A) *Raw Materials.*—The raw materials are those which enter into the make-up of the melting charge. They are defined by the chemical nature and their physical state. From the point of view of *chemical nature*, the charge can include:—(1) *Metallic components* called *virgin metals* of varying purity[2]; (2) alloys already carrying the same composition as the desired alloy. These may consist of *scrap*—foundry, machine shop, old (castings discarded through obsolescence); alloys cast as *analysed ingot*, that is to say of the desired composition; (3) *master alloys*, that is to say, alloys specially compounded under special conditions and of a composition different from that of the desired alloy; and (4) *additions* made with diverse objects, to be referred to later, and in particular including those destined to form melting fluxes.

The nature or chemical composition of virgin metals, analysed ingots, master alloys and additions is well known; this is not so, however, of scrap, and therein lies a grave source of difficulties and of failure in the foundry not possessing facilities for sorting and classifying scrap. Classification should be based on considerations of (*a*) the origin of the scrap which allows its general chemical composition to be established.

This chemical composition is known for that emanating from internal manufacture, that is, foundry scrap and customers' returns. In other circumstances it is necessary, or at least desirable, to undertake chemical analyses, or have recourse to some method of rapid characterisation or differentiation. For tests of a physical type, one can cite colour in the case of brass, fracture with cast iron, scratch hardness or bend test for light alloys. For composition tests there is, in the case of aluminium alloys, the "spot" test.[3] To avoid excessive analytical testing, ingotting embracing methodical mixing can be practised.

From the point of view of *physical state*, the size and shape of the pieces should be considered as much in the direction of rapidity of melting as in the sense of melting losses and changes. The question should therefore be examined in conjunction with melting processes and melting conditions to be dealt with later. For the present it will suffice to draw attention to reduction to suitable size which can be achieved by breaking up; by melting and casting into notched ingots; by shearing when the metal is malleable, or exists as malleable sheet or wire, or smashing up in the case of fragile materials.

B—Melting Conditions

Outstanding amongst conditions influencing the compounding of alloys, are the following:—B1—method of heating usually known as type of melting furnace; B2—melting atmosphere (or melting flux) and B3—nature of the furnace chamber or melting medium. Conditions B2 and B3 define the chemical nature of the external *milieu*, that is to say, the substances or gaseous phases (atmospheres), liquids (fluxes and slags) and solids (walls) in contact with the alloy and capable of reacting with it. They thus govern as a function of the temperature the changes of the metal; they are interconnected. The choice of atmosphere or melting flux must depend upon that of the furnace chamber and reciprocally. They are, however, equally in relation with the method of heating, as will be shown.

B 1—Methods of Heating and Type of Furnace for the Melting of Alloys

There are two major classes of furnace: (i) Combustion or flame furnaces, (*a*) shaft, (*b*) hearth and (*c*) crucible, and (ii) Electric furnaces, (*d*) resistance, (*e*) induction and (*f*) arc.

When choosing an alloy melting furnace, the following factors must be taken into consideration: (1) the precision of temperature control it is possible to impose, (2) thermal acceleration and (3) the atmosphere and refractory walls which can react with the charge or alloy. These last two factors will be examined later. Attention is drawn to the agitation of the liquid bath which characterises induction furnaces as this considerably increases the speed of homogeneisation; but it also enhances the reaction rate of the liquid bath with external surroundings.

The following remarks seem germane to the subject:—

Shaft furnaces are but little used, although this type of furnace has recently been tried out for brass melting.

Arc furnaces can only be practically employed for melting alloys of high melting point since the arc has a temperature of 3,700 deg. C. It is primarily used for making special steels, despite the risk of carburisation.

The hearth furnace is suited for the manufacture of large tonnages; there are drawbacks which result from its fundamental principle, and amongst these is the contact between the surface of the bath and the products of combustion.

It can thus be stated, for the sake of simplification, that there is the choice of three furnaces, the crucible, electric resistance and induction. Amongst factors deserving of consideration is that of the thermal acceleration, as it is often neglected.

Crucible furnaces heated by poor quality gas, and electric furnaces using metallic resistances show but slow temperature increase; oil-fired furnaces, on the other hand, have an important thermal acceleration.

Obviously, it is always worth while to increase the speed or reduce time of melting, because by so doing the heat losses through radiation and fuming (which are proportional to the length of time taken in melting) are reduced, and also, and often very seriously, the changes such as oxidation and gas absorption, to be considered later, are similarly reduced. It is, however, very important that the melting process should allow of a precise temperature control, and if possible it should also bring about the mixing of the melted materials. In this respect the introduction of the induction furnace into the brass foundry has brought a better uniformity and very low zinc losses.

B 2—Melting Atmosphere

The atmosphere or gaseous phase in contact with the metal should be considered from a dual aspect—its chemical nature and pressure. Leaving aside precious metals for which there is no alteration in air, at normal pressures, it is possible to postulate the following diverse cases of melting:—

(1) *Melting without chemical change*, by carrying out melting *in vacuo*, under conditions of an inert or inactive gas or an atmosphere in equilibrium or a protecting flux.

(*a*) *Melting under an inert or inactive gas*, as, for example, the melting and casting of refined copper in hydrogen or nitrogen or mag-

* Paper presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.

nesium or calcium in argon.[4] It is worth noting that certain metals combine with numerous gases in considerable quantity, as is the case with calcium or magnesium in contact with oxygen, nitrogen and hydrogen. On the surface of the bath, a local atmosphere can be created, as for example carbon monoxide, by dry or well-burnt charcoal.[5]

(*b*) *Melting under an atmosphere in equilibrium.* This would be the case with steel, in an atmosphere of $CO + CO_2$ or $H + CH_4$ in proportions defined by the temperature and the carbon content of the metal. Accordingly, there will be carburisation or decarburisation.

(*c*) *Fusion under a protecting flux.* It is essential that this flux be practically impermeable to gas of the atmosphere above it, as under these conditions it tends to put itself in chemical equilibrium simultaneously with the metal and the atmosphere, which latter causes reaction between these two phases. This leads in certain cases to the use of considerable thicknesses of flux, if an excellent protection be sought. An example is afforded by the method of melting magnesium used by Dow Chemical Company (60 per cent. $MgCl_2$ + 40 per cent. KCl or NaCl). The weight of flux is from 45 to 50 per cent. the weight of the metal being melted and serves at the same time to protect it against the atmosphere and the walls of the crucible.

(*d*) *Melting in vacuo.*— The phrase defines melting under negative pressures of the order of 0.01 to 1 mm. in furnaces of small capacity, and from 1.0 to 2 mm. for larger furnaces (in practice 4-ton furnaces are used for the casting of nickel alloys and special steels).

If vacuum melting is advantageous in respect to non-oxidation and degasifying (extremely variable factors, being very effective in the cases of palladium and tantalum and feeble with aluminium), yet contrarily it introduces certain troubles[4] especially in pronounced vacua (< 0.01 mm.) for there are such factors as the vaporisation of the metal through boiling, distillation or evaporation, and sublimation; the vapour tension of metals increases exponentially with temperature ($\log p = -\frac{a}{T} + b$). Thus, Mg, Ca and Be are purified by sublimation; iron of which the boiling point is 3,235 deg. C. sublimes at 1,300 deg. under sufficient vacuum. Chromium possesses, when approaching its melting point, a vapour pressure so great that it cannot be so melted, because it sublimes prior to this. The melting of a metal under high vacuum is thus only possible by creating a reduction of section and so bringing about a stagnation of vapours at the surface of the metal bath. To overcome this, there is the possibility of introducing either inert or neutral gases, especially some rare gases, so as to obtain pressures of a few millimetres.

Interesting factors in this connection are (*a*) the reduction of even refractory oxides forming the walls of furnaces by the carbon of the metal as is the case with steels and cast irons, or various metals such as Ti, W, Al, etc., and (*b*) the vaporisation of the materials incorporated in the construction of furnaces and notably the heating elements such as Nichrome, Pt, Mo, etc.

(2) *Melting with Chemical Change.*—This is the general case in the foundry with an atmosphere formed by air or furnace gases. As a result there is oxidation and maybe nitrogenisation (in the case of Mg and Ca) simultaneously with gas absorption. In this respect it should be pointed out that the presence of small quantities of compounds decomposing when hot in the presence of metal, such as water vapour, or ammonia gas has a very active action by liberating the gaseous elements to the atomic state whence follows a serious absorption of H and N. There are chemical changes of which the magnitude varies within wide limits according to the metals melted and the physical state of the products of reaction, as will be shown later.

Yet it should not be necessary to present the simple or cumulative change as a general and necessary result, since remelting can be exactly a purification process of a "changed" metal. Even oxidising conditions during melting—a process commonly used in metallurgy (as for instance in the production of copper and iron)—can be usefully used in the foundry (as in the case of the elimination of the Fe and Al impurities in tin alloys.

(3) *Melting with Refining.*—This refining can be undertaken by the general processes of chemistry, such as:—

(*a*) *Simple decantation.* For example, the undisturbed melting in the crucible of cemented bar and so eliminating the numerous silicate inclusions, or again the passage of pig-iron through the mixer brings about by decantation the separation of the manganese sulphide.[7] Magnesium, as received from the electrolysis plant, can be freed by this means from practically all the included magnesium chloride (the Cl content can be reduced from three to <0.01 per cent.). Tin and its anti-friction alloys when changed by contamination with iron from the melting chamber contain the heavier $FeSn_2$, which can be reduced down to something of the order of 0.1 per cent. of Fe.

(*b*) "*Sticking*" *or coagulation with weight increase.* By an addition of a mixture of MgF_2, $BaCl_2$, etc., to molten magnesium, the former spreads itself slowly through the liquid and induces a coagulation of the inclusions (Hérenguel, Thesis, Lille, 1936, p. 30) just as albumen is used for cleaning wine.

(*c*) *Filtration.* This process is very seldom used on account of the difficulty of finding filters sufficiently resistant to the action of hot liquid metals, in a manner similar to the cold filtration of mercury through chamois leather. It is, however, possible to point to the case of the forced filtration of magnesium through a metallic cloth sheet and perforated iron sheet (Hérenguel, Thesis, Lille, 1936, p. 31).

(*d*) *Extraction or Absorption by Flux or Slag.* This is the general process of metallurgy used in connection with steel, iron, copper, etc. All hearth furnace metallurgy, the Siemens furnace or the electric furnace is based on the use of slags which allow a charge entirely made up from scrap from any source; the use of soda ash brings about a rapid desulphurisation of cast iron.

All the reactions are, generally speaking, considerably accelerated by movements giving an emulsion and thereby materially increasing the surface contact (Ugine-Perrin process). Moreover, it can be stated that the deterioration of metal during melting is the result of poor technique. Changes of a metal or an alloy due to atmosphere can take place during casting, and hence the casting processes carried out in hydrogen or other gases, as for example in the case of refined copper, which is beyond the scope of this Paper. To simplify matters, it is proposed to consider in what follows solely the melting in air or in the furnace gases under normal pressure with or without a flux.

B 3—Furnace Chamber or Melting Medium

Refractory materials used as furnace fabrics[8] such as crucibles, pans, hearths, etc., are either oxides or oxidised products (silica, alumina, silicates of alumina, magnesia, zirconia, beryllia, chromite, etc.) or carbon (graphite) or carbides (silicon carbide, etc.) or perhaps metals (iron, cast iron, etc.). They react on the molten metal and the metallic oxides formed during melting, as well as on the fluxes responsible for or accelerating the changes in the metal. A study of these reactions would require a complete chapter of chemistry to deal with it, so it is proposed therefore only to give some short and much simplified indications applicable to normal conditions of melting. These depend upon temperature and pressure, as has already been shown when dealing with melting *in vacuo*.

Generally speaking, it is necessary to distinguish between cases where the refractory is of an acid or basic character, carburising and oxidisable or reducible.[9a] Basic linings are used for metals giving basic oxides and for basic fluxes. These include magnesia, beryllia (except for the carbonates) and chromite (which is neutral). Acid linings are used when there are acid products, such as silica (except for the fluorides), zirconia, alumina (except for silica); recourse can also be had to chromite and silicates of alumina (neutral).

Neutral linings such as chromite and silicates of alumina or magnesia are fairly difficult to attack in both cases. Carburising and oxidisable materials oxidise in air at high temperatures (about 1,650 deg. C. for graphite and 1,700 deg. C. for silicon carbide). They will resist solid oxides, most are reduced by fusible oxides (of Cu, Fe and Ni). Silicon carbide, which is both carburising and siliconising, reacts not only on the easily reducible oxides, but on metals such as Fe, Co, Cr, Pt, all melting at high temperatures.[9b]

Iron can be used for melting metals immiscible with it, such as Na, Pb, Mg. Even Sn, which alloys with iron and iron alloys, can be so melted, under the condition that the cast iron used is of poor mechanical quality, that is to say, carrying large graphite flakes (which prevent further progress of the dissolution of the iron).

In the changes in metal during melting, which often show up in a lowering of the mechanical properties, it is necessary to remember the chemical rôle of the furnace chamber. For example, repeated remeltings of tin and antifriction metals give a fragile metal, designated "burnt." These changes are attributed to oxidation since they are due to the presence of a definite compound $FeSn_2$ formed by the action of the iron in which the melting was carried out.

Here are shown all the complexities of changes during melting which dominate, as will be shown, the compounding of alloys. It is a veritable "introduction to the foundry" which can only be set out in general terms. Confining the subject to the normal conditions of the foundry, that is to say, without special atmospheres and using ordinary pressures, first of all, there will be postulated (1) the principles underlying the melting of industrial metals and this will be followed by (2) the principles of melting and the compounding of industrial alloys.

PART III—PRINCIPLES OF MELTING INDUSTRIAL METALS

The operation of melting a metal calls into play its calorific, physical and chemical properties. The *calorific* properties, specific heat, latent heat of fusion, are only to be considered in the light of choice of furnace from the angle of the requisite *speed of melting*, the importance of which has already been stressed. These factors have been the subject of determinations by various authors (Endo, Toepler, Vincentini and Omodei, Bornemann and Sauerwald, Wrightson, Saburo, Umino, Schwartz, etc.).[9] The consideration of physical constants, *melting temperatures* θ_f and boiling points θ_e lead with that of *chemical properties at high temperatures* to the conception of an *interval or margin of temperature* for *superheated liquid* $\theta_s - \theta_f$ for a *metal and fixed conditions of melting*—an interval in which it should be possible to hold it in the actual practice of the melting of that metal.

The lower limit θ_f is precisely defined and in absolute terms by the *melting* temperature. The upper limit θ_s or the limit of acceptable liquid superheating is a function of several phenomena and it is defined with very much less precision, due to the presence of a number of variable factors. The phenomena of limiting character which intervene are:—

(1) Physical: boiling and volatilisation.

(2) Chemical: consisting principally of the action of the gases of the atmosphere, either oxidation or absorption of gases (H, N, CO, etc.) and, secondly, of the reaction on the walls and the fluxes. To these could be added

(3) Crystalline, corresponding with the total disappearance of the crystalline organisation through melting and corresponding to the phenomena of crystalline superheating having their repercussion on the crystallisation after melting, but the few serious factors actually available in this respect correspond to relatively small temperature margins of which there is no need to take account in practice.

It is thus worth while to examine the consequences that may be deduced from boiling, from oxidation and from absorption of gas.

(1) *Boiling.* Primarily, it is obvious that the boiling point θ_e is in every case the upper limit of the admissible temperature $\theta_s < \theta_e$ which may represent the melting conditions. The difference $\theta_e - \theta_f$, the boiling and the melting points of metals, is most frequently the greater the more the metal is refractory.

R. Lorenz and Walther Herz[10] have shown that the ratio $\frac{T_f}{T_e}$, the absolute melting and boiling points, was on an average 0.5583 for elements; 0.7183 for inorganic substances and 0.62 as a general average for 412 substances—elements, organic and inorganic bodies. In one case only, that of tin gave a ratio well under 0.198.

On the other hand, Professor G. Longinescu[11] has established the ratio $T : d\sqrt{n} = K$, a constant, where—

T = absolute melting or boiling point.

d = density in the solid or liquid state.

n = number of atoms in the molecule.

K = 50 for the solid state and 100 for the liquid state.

As the relation of solid and liquid densities is ranged between 1 and 1.2, it therefore follows that $\frac{T_f}{T_e} = 0.5$ to 0.6.

It can be concluded that

$$\theta_e \overline{\sim} 1.8\ \theta_f + 218.$$

$$\theta_e - \theta_f \overline{\sim} 0.8\ \theta_f + 218.$$

In fact, taking into consideration the latest published values for these physical constants, it has been found that $\frac{T_f}{T_e}$ is :—

0.7 for Mo (a relatively volatile metal).

0.6 to 0.7 for W, Cr, Fe, Ni, Co, Mg.

0.5 to 0.6 for Ti, V, Mn, Au, Ag, Cu, Cd and Zn.

0.3 to 0.5 for Al, Sb, Pb, Hg.

0.2 for Sn (a metal notably stable in the liquid state).

As has been stated, vaporisation taking place before boiling limits the margin of liquid superheating, the knowledge of θ_s in addition supplying a point of the exponential curve of vaporisation ($\log p = \frac{a}{T} + b$) determined for a number of metals (Na, Zn, Mg, Ca, Al, Cu and Be) by various authors (Pilling, Rodebusch and Walters, Bauer and Brunner, Rudberg), the coefficient b of the formula being of the order of 7 to 9. For example, in air, under atmospheric pressure, the evaporation becomes noticeable when the temperature exceeds 715 deg. C. for zinc, 626 for lead and 1,023 for silver (Krupkowski and Balicki), of which the boiling points are respectively 918, 1,740 and 2,100 deg. C. The margin of superheating is, however, notably restricted by the chemical changes.

(2) *Chemical Change.*—This may be due to α, the melting change expressed either by the oxygen content or impurity absorbed or, inversely, the loss of an element, or again the lowering of a property, a foundry property (such as running power), a mechanical property, soundness, etc. On the other hand, this change or quality-depreciation is a function of the temperature of the liquid metal θ, of the melting period t and of the surface S of contact with external surroundings.[12]

$$\alpha = f(\theta, t, S)$$

Again, the *admissable change* through melting depends not only on the *limit of change* laid down for the metal, but also in the case of quantity production on the re-use of scrap[13] of *mise au mille*,* M, and the proportion of scrap r. This question has been analysed by R. de Fleury[14] who, in dealing with this subject drew some remarkably simple conclusions by pointing out that change in quality through melting was independent of the initial state before melting, that is to say reproduces itself with the same intensity at each remelting. Thus if N is the number of remeltings necessary so that constantly remelting the same quantity of metal of the initial quality Q_σ, one may cause this quality to fall to the lower level Q_l, there is

$$Q_\sigma - Q_l = N\alpha \quad . \quad . \quad . \quad (2).$$

If, on the other hand M is the *mise au mille*, that is to say the relation of the weight of the charge to be melted, or the charge, to the weight of the castings obtained, the number n of operations depreciating the metal to the lower limit of value Q_l will be given by the exponential equation :—

$$(1 - \alpha)^n \frac{(M - 1)^n}{M} = \frac{M - N}{M - 1} \quad . \quad (3)$$

and for an equilibrated manufacturing system taking back for remelting all the scrap made, might continue without reaching finality, thus

$$M \leqslant N(1 - r) \quad . \quad . \quad (4).$$

These formulæ demonstrate the interdependence of M, r, N, Q_l and α. M and r are essential to the conditions of technical and professional exploitation as upon them depend the conception and carrying out of moulding, notably in respect to feeding heads and the feeding of castings.

Q_l is a limited quality which can on occasion be defined in particularly clear terms, but in other cases quite unprecisely and in an arbitrary manner dependent upon specifications and inspection conditions. For example with Alpax (aluminium-silicon approaching eutectic composition) there is a sharp drop in the mechanical properties when the iron content reaches 0.8 per cent. Again, for other alloys quite small variations in titanium have a very appreciable effect. Yet, most frequently, the change in properties is progressive and the limit is conventional.

Given a proper picture of the manufacturing conditions and the values Q_σ and Q_l, N and consequently α are thereby limited and thus for any given conditions of melting, notably the time of melting t, one can define from equation 1 a limited value θ_s for θ.

Putting aside contamination by solid contact (walls and tools) and if the chemical change by the free surface only be taken into consideration, that is to say, the atmosphere by oxidation or gas absorption, S becomes the surface of the bath, which it seems worth while to reduce, bestowing advantages from the point of view of furnace chambers or deep crucibles and even those narrowed towards the top.

The oxidation of metals in the liquid state has been the subject of a noteworthy research by Krupkowski and Balicki, who showed, so far as it takes place for the oxidation of metals in the solid state, the important part played by the physical state of the oxidised layer formed on the surface.

In the isotherm condition in air the rate of oxidation is low and constant if the oxide formed is insoluble and solid ($W^2 = Kt$).

The rate of oxidation is rapid if the oxide formed is soluble in the molten metal or is insoluble and liquid ($W = Kt$). In an unchanged atmosphere of air (as for example in a tall crucible) oxygen is absorbed and the speed is controlled by its diffusion in the air. The insoluble solid oxides therefore play the part of protectors, and this can be profitably used to protect metal during melting and during casting by small additions of oxidisable elements such as Al, Si, P, etc.

On the other hand there is a sharp increase in the rate of oxidation when insoluble oxide becomes liquid, that is to say, when the invariant temperature of the two phase liquid oxide-metal system is exceeded as, for example, in the case of Cu-CuO_2 at 1,200 deg. C. This often supplies a value to the limit of superheating θ_s but, moreover, this limit can also result in a rapid increase in the rate of oxidation resulting from the exponential amount of the phenomenon in relation to the absolute temperature T ($\log W = -\frac{K}{T}$).

Knowledge of the absorption of gases is less advanced; if various investigators (Sieverts, Iwasé, Lückemeyer, Haase, Schenck, etc.) have given solubility values in relation to temperature, the rates of absorption are scarcely known. Seemingly they ought to be in relation to the temperature to conform to the corresponding laws for oxidation, everything connected with it being profoundly influenced by state—atomic or molecular—of the gas.[15] It is in this manner that the presence of water vapour or ammonia is responsible for a rapid absorption of H and N by various metals (Al, Fe, etc.), and that, on the other hand, it is important, from the point of view of the rapidity of the absorption of gases, not to exceed certain temperatures, as, for example, 900 deg. C. for aluminium in the presence of hydrogen. There is once again, from this point of view, an upper limit θ_s for the margin of liquid superheating.

(To be continued.)

* *Translator's Note.*—No equivalent expression has been found for this phase, which is the relationship between the weight of the charge to be melted and the weight of the castings obtained.

REFERENCES.

1 Lessons by R. Lemoine on the compounding of copper alloys, and by P. Bastien on the compounding of aluminium alloys. Worthwhile reference has been made to M. Dannenmuller on compounding antifriction alloys.

2 "Purity" should perhaps include elements not usually analysed, such as gases. Gases may be more abundant in certain types or under certain conditions of compounding. For example, the gas content of aluminium depends on the electrolysing conditions.

3 The classification of scrap has been well set out for aluminium alloys, both from the mechanical and physical aspects, by Bosshard, and rules for admissible and inadmissible mixes have been formulated by Irmann. Their results are worth studying and amplifying.

4 See Herenguel, Lille Thesis, 1936, p. 10.

5 Under certain conditions, charcoal ash can react with the metal. For instance, in lead baths, it forms silicates from its ash.

6 See W. Kroll, Zeit. Elektrochem., Vol. XLII, 873, 1936.

7 Keeping aluminium in a stand-by furnace before casting, formerly carried out, should have resulted in a decantation, not of the alumina, as would be thought (an illusory decantation because of too small a difference in density), but of gas inclusions.

8 Everything written in connection with furnace chambers naturally applies to all solid materials in contact with molten alloys, such as those used for stirring or for the introduction of materials forming the charge.

8a Data upon the attack of refractory-lined furnace chambers by metal, oxides and molten salts are to be found in the research work of R. Winzer (Angewandte Chemie, 1932).

8b The action of silicon carbide on the metallic oxides of Al, Ca, Co, Cu, Cr, Fe, Mg, Mo, Mn, Ni, Tl, W has been dealt with by L. Baraduc-Muller (Rev. Met., VII, p. 683, 1910).

9 Résumés are to be found in the Appendices to the Metallographic Course of the French Foundry School, pages 1 to 5, 1936 edition.

10 Zeit. an. allg. Chemie, **94**, 1 and 24 (1926); **122**, 51 (1922).

11 Journ. Chim. Phys., (1903), p. 289, 296, 391; Bull. Chim. Soc. roumaine Sci., XXVI, Dec., 1923.

12 In this connection it is germane to point out that the change, everything being equal and for furnace chambers geometrically the same, decreases with the mass of metal to be melted, since it increases with the surface S, which should be in relationship with the mass unit M and that the ratio $\frac{S}{M}$ decreases as one of the linear dimensions, depth or width of the liquid bath. Also, unless special precautions are taken, there is no advantage to be gained from laboratory meltings using small masses for the study of alloys.

13 It is to be understood that no regard is paid to the contamination resulting from the introduction into the bath of foreign substances mechanically entrained, such as metallic powders, oxides, slags, sands, which result from carelessness.

14 Fundamental importance of *mise au mille* in foundry practice. Bull. A.T.F., XII, p. 2, Jan.-Feb., 1938.

15 As a natural consequence for the melting of metals prone to the absorption of gas, there is a series of practical precautions: Melting as rapidly as possible; thus charge the materials into the furnace and the furnace chamber as hot as possible; avoid reducing atmospheres in pan furnaces; in crucible practice avoid dampness in the fuel, atmosphere or tools; reduce the time of contact with the atmosphere whenever dealing with liquid metals.

Turkish Iron Ore Deposits

An interesting description of the magnetite deposits in the Divrik district of Turkey which occur associated with tourmaline, is contained in memoir 3, series B, of the Turkish "Publications de l'Institut d'Etudes et de Recherches Minières de Turquie," Ankara. It is pleasing to find that the author (Mr. V. Kovenko) makes his report available to a much increased technical public by writing it in both Turkish and French, the French translation being excellent.

The Week's News in Brief

Trade Talk

BIRMINGHAM REFRACTORIES, LIMITED, have removed to more commodious premises at 27, South Road, Northfield, Birmingham, 31.

MESSRS. JOHN STEEL, manufacturers of engineering equipment, of Clyde Mills, Bingley, Yorks, have recently moved into larger premises, taking over a factory which provides greatly increased floor space.

THE OFFICES of the Iron and Steel Trades Confederation have now been transferred to Rooms 223, 225 and 226, Gazette Buildings, Corporation Street, Birmingham, 4, where all correspondence should be addressed.

METAL INDUSTRIES, LIMITED, are breaking up at their Rosyth yard the German steamer "Ilsenstein," of 8,216 gross tons, which is one of the few vessels from that country to be sold to British shipbreakers within recent years.

MONOCHROME, LIMITED, of Montgomery Street, Birmingham, have acquired a site of 5½ acres at Redditch and the work of building a factory has begun. The company specialises in a new process of chromium plating.

MR. SEAN F. LEMASS, the Eire Minister for Industry and Commerce, recently opened a new steel mills at Haulbowline, Cork Harbour. The mills are ready to begin production, and, it is said, will supply Eire's entire steel requirements.

THE BRITISH MOULDING MACHINE COMPANY, LIMITED, of 237, Weston Street, Bermondsey, London, S.E.1, have been reluctantly compelled to withdraw from the forthcoming Foundry Exhibition on account of urgent Government contracts passing through their shops.

A MEETING of the Low Moor Iron Company, Limited, will be held at Lincoln House, High Holborn, London, W.C.1, on September 26, at noon, for the purpose of showing the manner in which the winding-up has been conducted and the property of the company disposed of, etc.

RECENT ADDITIONS to the foundry plant of Craven Brothers (Manchester), Limited, include two 40-ton electric overhead travelling cranes by Vaughan; an escalator by Morris of Loughborough for returning scrap to the cupola platform, and a large extension to the charging stage by Pearson & Knowles, Limited.

REFERENCE was made recently in a speech by Mr. G. H. Latham, chairman and managing director of the Whitehead Iron & Steel Company, Limited, to the new factory that is to be established adjoining the firm's works at Courtybella, Newport. He said the arrangements had been completed, and the factory would take considerable quantities of the products of their works.

IT IS REPORTED that the Chinese Government Purchasing Commission has placed an order with a number of British rail makers for £250,000 worth of rails for the new railway which is being built to connect with the French railway through Indo-China. The first consignment of rails is to be shipped at the end of September, and the whole order is to be completed within the shortest time possible.

EMPLOYEES OF THE English Steel Corporation, Limited, participated in an A.R.P. demonstration at the various works at Sheffield last week. The rehearsal was efficiently carried out and with the minimum of delay immediately the sirens sounded. At the same time steps were taken to stop or slow down certain plant in order to prevent glare or steam being seen. Only essential services, such as the power stations, would be kept going. There are 11,000 to 12,000 people employed by the firm at the Sheffield works, and 7,500 is the maximum number on a day shift.

Forthcoming Events

SEPTEMBER 9.

Keighley Association of Engineers:—Outing to Malham, leaving Arcade Chambers, North Street, Keighley, by coach at 2 p.m.

Institute of British Foundrymen

SEPTEMBER 9.

West Riding of Yorkshire and Lancashire Branches:—Visit to English Electric Company's works at Bradford, at 3 p.m.

THE Ministry of Labour returns of the building trade for last month were unsatisfactory, and reveal that there was a decline of 30.9 per cent. in the total value of plans passed during the month, as compared with the corresponding month of last year. This is largely attributable to the absence of a satisfactory war risks insurance scheme for property, and housebuilding plans were lower by 39.2 per cent. on the year. Plans for shops and business premises were down by 38.9 per cent., which compares with a rise of 40 per cent. in June. The only section to show an increase in July was factory plans, which were higher by as much as 115.4 per cent. on the year. The fall in the total value of plans passed in July is the largest decline ever to be recorded.

THE ENGINEERING AND MARINE EXHIBITION, with which is incorporated the Foundry Exhibition, opens at Olympia, London, on September 14, and the organisers (F. W. Bridges & Sons, Limited, Grand Buildings, Trafalgar Square, London, W.C.2) inform us that they are again issuing tickets to employers for distribution amongst their staffs at the specially low rate of 3s. per dozen (free of entertainment tax). Works executives proposing to organise parties to visit the exhibition should communicate with Thos. Cook & Son, Limited, Berkeley Street, W.1, who will advise them regarding cheap fares, etc. The exhibition will remain open from 11 a.m. to 9 p.m. daily (except Sundays) until September 30, the cheap tickets being available for any single day.

Personal

DR. JOSEPH WARD, J.P., chairman of Thomas W. Ward, Limited, on whom Sheffield University recently conferred the degree of LL.D., has presented to the directors a painting of himself by Ernest Moore, the well-known artist. The portrait is considered a very striking one, and has been

PAINTING OF DR. JOSEPH WARD, J.P.

hung among other paintings in the board room, at Albion Works, Sheffield. In 1931-32, Dr. Ward was Master Cutler of Sheffield, and has occupied many important official positions both local and national. He has been a member of the Applied Science Committee of the Sheffield University for 15 years, latterly its chairman, and last year he was appointed treasurer of the University. He is still actively associated as chairman and managing director with the parent organisation and subsidiary companies of Thomas W. Ward, Limited.

MR. WM. A. GIBSON, the well-known Australian consulting engineer, left Southampton by air last Saturday for Sydney.

MR. E. W. HARDING (of the International Meehanite Metal Company, Limited) has changed his home address from Barkingside to 42, Swan Court, Chelsea, London, S.W.3.

Company Reports

Blakey's Boot Protectors, Limited.—Final dividend of 7½ per cent., making 15 per cent., less tax.

Ley's Foundries & Engineering, Limited.—Dividend of 2½ per cent. on the 5 per cent. cumulative preference stock for the half-year ending September 30.

Davey, Paxman & Company (Colchester), Limited.—After depreciation, directors' fees and N.D.C., profit for year ended March 31, £22,038; less interest on debenture stock, £3,360; brought forward, £11,925; available, £30,603; dividend on ordinary 15 per cent., less tax; carried forward, £11,919.

Contracts Open

Godalming, September 4.—Supplying and laying new water mains as follow:—280 yds. of 4 in. cast-iron main and specials; 150 yds. of 6 in. cast-iron main and specials; 25 yds. of 4 in. cast-iron main and specials, for the Town Council. Mr. E. G. Bowyer, waterworks engineer, 35, Bridge Street, Godalming. (Fee £1 1s., returnable.)

Whitstable, September 4.—Cast-iron pipes and special castings, for the Urban District Council. Mr. G. Dunkin, surveyor, Surveyor and Water Engineer's Department, Council Offices, The Castle, Whitstable.

Obituary

MAJOR JOHN GRAHAM YOUNG, a director of Glenfield & Kennedy, Limited, Kilmarnock, died on August 23 at the age of 57.

MR. ARTHUR BEARDSHAW, proprietor of Jos. Beardshaw & Company, Acme Steel Works, Attercliffe, Sheffield, died on August 23 at the age of 82, after a short illness. He had been connected with the steel trade for 60 years.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

British Slug Making & Annealing Company, Limited, 92, Bromwich Road, Worcester.—Capital, £15,000. Directors: A. L. Miller, E. G. Lewis, and R. Cox.

Wellman Bros. & Company, Limited, 42/43, Peascod Street, Windsor.—Capital, £20,000. Brass and iron founders, etc. Directors: C. J. U. Hussey, F. J. Young, W. A. Cooper, E. E. Green, and Angela M. Cawley.

(Situations continued from p. 16)

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

FOUNDRY PLANNING ENGINEER and Foreman Patternmaker desires situation, considerable experience in both capacities. Specialist in pattern and equipment design for modern production. (360)

YOUNG MAN requires progressive position as Technical Assistant or in a similar capacity. Excellent practical and technical experience in patternmaking, foundry work and metallurgy, including cupola control. Go anywhere. (361)

FOUNDRY WORKS MANAGER desires similar position or as Foundry Manager. Experience with general castings up to 20 tons; also considerable experience in repetition work on heavy sanitary castings. (362)

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•

CUMMING CORE
COMPOUNDS

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CORE GUM
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WM. CUMMING
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Branches at
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LONDON OFFICE: SENTINEL HOUSE, SOUTHAMPTON ROW, W.C.1.

Raw Material Markets

Ferrous and non-ferrous metals have been subjected to the unsettling effects which the threat of war has imposed on all commodity markets during the past week. The slowing down of commercial activities has not affected production, however, and operations at the works continue to be at or near maximum capacity. Output of pig-iron has been further increased, but the additional tonnage is going to the steelworks, for the most part, little increase having taken place in the requirements of the foundries, except for special grades.

Pig-Iron

MIDDLESBROUGH—The small output of Cleveland foundry iron is fully absorbed, but there are no indications that production is to be increased. So far, foundries have been able to secure adequate supplies from other areas, but in certain circumstances the absence of stocks of this grade of iron might be a matter of concern to users. At the moment, however, there is no question of a shortage, and users of high-phosphorus iron can get all the supplies they require. Hematite demand is active. Much of this area's production goes into the steelworks, and requirements are now on such a scale that an increase in demand could only be met from stock. Reserves at furnaces are still considerable, but prospects of their early liquidation are now more favourable.

LANCASHIRE—The light-castings trade in Lancashire is not particularly busy, and a further slackening is promised. Trade in high-phosphorus iron is therefore relatively slow, although deliveries are so far maintained. Jobbing foundries are slightly better placed, though the improvement is not very great. Easy conditions continue in the textile-machinery department also, but the heavy electrical engineering and machine-tool trades are very busy and are absorbing a good tonnage of pig-iron. The demand for hematite continues to expand.

MIDLANDS—Fresh business this week in the common grades of pig-iron has been small, but low- and medium-phosphorus descriptions are moving away very well. Makers of these grades are now full up with orders, and this has reacted on hematite, which is being taken by some users in substitution. The price of low-phosphorus iron has moved up, and quotations now range from £5 10s. to £6 7s. 6d. delivered the Midlands, according to quality, tonnage, and the length of railway haul. Low-phosphorus iron is a free market and, prices not being controlled, reflects fluctuations in demand more readily than is the case with common irons.

SCOTLAND—The light-castings makers are still experiencing a slack demand, and their pig-iron requirements fail to improve, but generally there is a firm market in pig-iron. Production of steel-making grades is being further increased. Buyers of foundry iron are still not inclined to buy very far ahead, although there has been a greater readiness to enter the market this week, in view of the critical situation.

Coke

Blast-furnace coke is in good demand, and with a big export trade in addition, most makers are fully sold for some time ahead. Supplies are moving freely to the furnaces, and requirements are being met. The foundry coke market is quiet, though firm. No alteration in prices is expected before the end of the year, except in exceptional circumstances.

Steel

Increased pig-iron production and larger importations of scrap have eased the position of the steelmakers with regard to supplies of raw materials. The re-rollers, however, are as anxious as ever to secure supplies of billets and sheet bars, and do not seem in all cases able to get their full requirements. The pressure for all finished steel products continues. Rolling dates are becoming extended, and the works are not at all anxious to book fresh orders for some products. Sheet mills are working to capacity.

Scrap

Importations from abroad are not sufficient to make the scrap position easy, and steelmakers, though relieved of anxiety, are glad to take all the scrap which becomes available from home sources. Cast-iron scrap is in steady demand, and there has recently been an increased call for light material, which has sent prices to higher levels.

Metals

Prohibition of exports, higher war risk insurance rates, and the fluctuations in sterling on New York have all helped to impose restraint on operators in the non-ferrous metal markets, already restricted under the influence of the serious political situation. In the event of war, speculation in metals would presumably be stopped and price control exercised by the Ministry of Supply. At the same time, removal of output control is to be expected. The Board of Trade, in order to conserve stocks in this country at the present time, has prohibited the export to foreign countries of tin, copper, lead, spelter, and other non-ferrous metals, except under licence. Prices of most metals dealt in on the London Metal Exchange have moved up. Copper and lead this week reached new high levels for the year.

Copper—This market is in a strong position. Consumption is well upheld, and although market interest during the past week has been comparatively small, a firm tone is maintained. Only a small tonnage is believed to be held by speculators. The large sales to Germany which recently were a feature of the market have ceased under the Board of Trade order.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £44 to £44 1s. 3d.; Friday, £45 7s. 6d. to £45 10s.; Monday, £45 16s. 3d. to £45 18s. 9d.; Tuesday, £46 5s. to £46 6s. 3d.; Wednesday, £45 10s. to £45 12s. 6d.

Three Months.—Thursday, £44 2s. 6d. to £44 1s. 3d.; Friday, £45 8s. 9d. to £45 10s.; Monday, £46 2s. 6d. to £46 3s. 9d.; Tuesday, £46 7s. 6d. to £46 10s.; Wednesday, £45 16s. 3d. to £45 17s. 6d.

Tin—Consumption of tin is well maintained both in this country and on the Continent, and absorption by United States users is also upheld. The political situation, of course, dominates the market and discussion of the future of the metal is useless.

According to the Statistical Bulletin of the International Tin Research and Development Council, world tin production in the first half of 1939 amounted to 62,800 (previous year 82,500) tons, of which 48,382 (previous year 67,984) tons were accounted for by the signatory countries. The visible supply during the first half of 1939 shows an increase of nearly 2,000 tons, whereas the carry-over and smelters' stocks decreased by 12,000 tons. The total stocks show, consequently, a decrease of about 10,000 tons to 39,387 tons. During July the total stocks increased by 125 tons to 39,512 tons, representing 26 per cent. of the current annual rate of consumption. World apparent tin consumption in the first half of 1939 at 74,900 tons was 6,000 tons below consumption in the first half of 1938, but 4,000 tons above that in the second half. There was a decrease of 60 per cent. in the apparent consumption of Russia; most probably this country has been drawing on her stocks. World tinplate production in the first half of 1939 amounted to 1,900,000 tons, against 1,500,000 tons in the corresponding period of 1938, being an increase of 27 per cent.

Official quotations were as follow :—

Cash.—Thursday, £229 17s. 6d. to £230; Friday, £229 17s. 6d. to £230; Monday, £229 17s. 6d. to £230; Tuesday, £229 17s. 6d. to £230; Wednesday, £229 17s. 6d. to £230.

Three Months.—Thursday, £222 17s. 6d. to £223 2s. 6d.; Friday, £224 12s. 6d. to £224 15s.; Monday, £226 2s. 6d. to £226 7s. 6d.; Tuesday, £226 10s. to £227; Wednesday, £226 15s. to £227 5s.

Spelter—Prices of spelter have now definitely moved up; for a long period they were slow to respond to the improvement which has taken place in consumption. This country is largely supplied from abroad and the war risk has thus had a lot to do with the advance. Furthermore, spelter is an important war material. The future of the metal, like that of others dealt in on the London market, is dependent on the international situation.

Daily market prices :—

Ordinary.—Thursday, £14 8s. 9d.; Friday, £14 16s. 3d.; Monday, £15 5s.; Tuesday, £15 2s. 6d.; Wednesday, £15.

Lead—The lead market has maintained a firm tone. Consumption for armament purposes is heavy. The recent increase in prices is largely due to the break in sterling.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 17s. 6d.; Friday, £16 5s.; Monday, £16 12s. 6d.; Tuesday, £16 7s. 6d.; Wednesday, £16 10s.

Scrap—Trade in non-ferrous scrap metals is rather more active and the markets reflect the improvement in virgin metals.

MACHINERY FOR SALE—*Continued from page 16*

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & Co., LTD., Station Works, Ecclesfield, Sheffield.

MISCELLANEOUS

MACHINE-TOOL CASTINGS required, up to 3 tons, in regular quantities. Applications invited from high-class founders.—Apply Box 766, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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